RESEARCH REPORT 111

Explaining Child Malnutrition in Developing Countries

A Cross-Country Analysis

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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Foreword

One in three preschool children in the developing world is undernourished. As a consequence, their human rights are violated. In addition, they are more likely to have impaired immune systems, poorer cognitive development, lower productivity as adults, and greater susceptibility to diet-related chronic diseases such as hypertension and coronary heart disease later in life. Undernourished female preschoolers are likely to grow into undernourished young women who are more likely to give birth to babies who are undernourished even before they are born, thus perpetuating the intergenerational transmission of deprivation.

Reducing these unacceptably high numbers remains a tremendous challenge to public policy. As a guide to the direction of future efforts, this research report examines the success of the efforts of the past 25 years to reduce preschooler undernutrition. The report uses an econometric model to identify the factors associated with the reduction in undernutrition. The formulation of the econometric model is guided by the widely accepted food-care-health conceptual model of child growth. The contributions of both underlying and basic determinants to reductions in undernutrition are assessed using the model. The potential of these factors to further reduce undernutrition is evaluated in a region-by-region priority-setting exercise. In addition, projections of child nutrition are made under various scenarios to the year 2020. What will it take to dramatically reduce undernutrition in the next 20 years? The report attempts some broad answers to these questions. This work represents one component of IFPRI's 2020 Vision initiative and will continue to be updated periodically.

Because the results of this research are so important to policymakers, IFPRI is also publishing a less technical version of this report as a 2020 Vision discussion paper titled *Overcoming Child Malnutrition in Developing Countries: Past Achievements and Future Choices,* Food, Agriculture, and the Environment Discussion Paper 30, available in February 2000.

Per Pinstrup-Andersen
Director General

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Summary

Developing countries have made great strides in reducing child malnutrition over the past few decades. The prevalence of underweight children under five years of age in the developing countries was 46.5 percent in 1970. By 1995 it had dropped to 31 percent (167 million children), indicating that while past progress has been substantial, it still has a long way to go. This research draws on the experience of 63 countries during 1970–96 (1) to shed light on some of the main causes of child malnutrition, (2) to project how many children are likely to be malnourished in the year 2020 given current trends, and (3) to identify priority actions for reducing malnutrition most quickly in the coming decades.

The determinants of child malnutrition can be divided into three levels of causality: immediate, underlying, and basic. The immediate determinants are dietary intake and health status. They are influenced by three underlying determinants, on which this report focuses: food security, care for mothers and children, and health environment quality. Four explanatory variables represent these concepts: per capita national food availability (for food security), women's education and women's status relative to men's (for both food security and care), and safe water access (for health environment quality). The report also examines the role of two basic determinants that influence child malnutrition through their effects on the underlying determinants. These are economic resource availabilities and the political environment. The explanatory variables representing these two factors are per capita national income and democracy.

Of the explanatory variables that represent the underlying determinants, women's education is found to have the strongest impact on child malnutrition. It is followed closely in strength of impact by per capita food availability. As the amount of food available per person increases, however, its power to reduce child malnutrition weakens. Women's status relative to men's and the quality of a country's health environment also strongly affect child malnutrition. For the developing countries as a whole, however, these two factors do not have as strong an influence as women's education and per capita food availability.

Per capita national income and democracy are both important factors influencing child malnutrition. Per capita national incomes reduce malnutrition by increasing public and private investment in all of the underlying-determinant variables. Democracy

affects child malnutrition at least partially through improvements in safe water access and increases in per capita food availability.

One of the limitations of the study is that it is unable to consider the effects of food security or poverty on child malnutrition because sufficient data are lacking. However, it should be recognized that having enough food available per person at a national level is a necessary but not sufficient condition for that country to achieve food security; households must also be able to access available food in order to achieve adequate nutrient intakes for their children on a sustainable basis. Similarly, increases in the amount of income available per person are a necessary but not sufficient condition for reducing poverty. How the available income is distributed among a country's population is also important.

As a result of the strong influence of women's education and the substantial progress made in increasing it, women's education is estimated to be responsible for almost 43 percent of the total reduction in child malnutrition that took place from 1970 to 1995. Improvements in per capita food availability have contributed about 26 percent to the reduction, health environment improvements 19 percent. Because there was little improvement in women's status relative to men's over the 25 years, its contribution—while still substantial—was the lowest (about 12 percent). Through improvements in the underlying-determinant variables, increases in per capita national income have made a very large contribution—roughly 50 percent of the total reduction in the prevalence of child malnutrition during 1970–95. While increases in democracy have great potential for reducing child malnutrition, no progress has been made in this area for the developing countries as a whole, and therefore it has made no contribution.

If current trends continue, the prevalence of child malnutrition is projected to remain high in the year 2020, with roughly 20 percent of all developing-country children under age five, or 140 million children, malnourished. South Asia and Sub-Saharan Africa will remain the regions with the highest child malnutrition rates. The absolute numbers of malnourished children in Sub-Saharan Africa are expected to be *higher* in 2020 than they were in 1995. A sharp regional shift in the location of child malnutrition is projected: South Asia's share of the total number of malnourished children will fall from approximately 51 percent to 47 percent, but Sub-Saharan Africa's share will rise from 19 percent to near 35 percent.

However, the future does not have to look like the past. The findings of this report indicate that significant progress can be made toward reducing child malnutrition through accelerated actions in sectors that have not been the traditional focus of nutrition interventions. Increased investments in women's education, in raising food supplies (or reducing population growth), in measures that improve women's status relative to men's, and in health environments should be an integral part of strategies for reducing children's malnutrition in the future. These investments should be seen as complements to more direct nutrition interventions, such as breast-feeding promotion and nutrition education.

A key message of the report is that any comprehensive strategy for resolving the problem of child malnutrition must include actions to address both its underlying *and* basic causes. If national incomes and democracy are not improved, on the one hand, the resources and political will necessary to increase investment in health environments, women's education, women's relative status, and food availability will not be forthcoming. On the other hand, if national incomes and democracy improve, but additional resources are not directed toward improving the underlying determinants, the improvements will make little difference.

Given resource constraints and the costs of alternative interventions, how should policymakers prioritize investments to reduce child malnutrition most quickly? The investments that should receive priority will differ by geographical area because they differ in (1) the relative strength of the determinants' effects and (2) the current progress in reaching the determinants' desired levels. The top priorities in each developing region, based on consideration of these two criteria, vary greatly.

In Sub-Saharan Africa and South Asia—the regions with the highest rates of child malnutrition—improvements in per capita food availability and women's education offer the best hope for future reductions in child malnutrition. An additional secondary priority for South Asia is promotion of women's status relative to men's. In East Asia, the Near East and North Africa, and Latin America and the Caribbean, the primary priority is women's education and a second priority is women's status relative to men's. Additional priorities are food availability for East Asia and health environment improvements for Latin America and the Caribbean. To maintain the necessary resource base and political will for these investments, investments in national income growth and democratic development must be accelerated as well.

CHAPTER 1

Introduction

The causes of child malnutrition are complex, multidimensional, and interrelated. They range from factors as broad in their impact as political instability and slow economic growth to those as specific in their manifestation as respiratory infection and diarrheal disease. In turn, the implied solutions vary from widespread measures to improve the stability and economic performance of countries to efforts to enhance access to sanitation and health services in individual communities. Debates continue to flourish over what the most important causes of malnutrition are and what types of interventions will be most successful in reducing the number of malnourished children.

An understanding of the most important causes of malnutrition[1] is imperative if the current unacceptably high numbers of malnourished children are to be reduced. In 1995, 167 million children under five years old—almost one-third—were estimated to be underweight in developing countries (Table 1). The region with by far the highest prevalence, 50 percent, is South Asia. This region also has the highest number of malnourished children, 86 million (50 percent of the developing-country total). About one-third of Sub-Saharan African children and one-fifth of East Asian children are underweight. While the prevalence of underweight in the regions of the Near East and North Africa (NENA) and Latin America and the Caribbean (LAC) are below 15 percent, pockets of severe malnutrition within them, particularly in some Caribbean and Central American countries, remain.

Malnutrition causes a great deal of human suffering—both physical and emotional. It is a violation of a child's human rights (Oshaug, Eide, and Eide 1994). A major waste of human energy, it is associated with more than half of all children's deaths worldwide (Pelletier et al. 1995). Adults who survive malnutrition as children are less physically and intellectually productive and suffer from higher levels of chronic illness and disability (UNICEF various years). The personal and social costs of continuing malnutrition on its current scale are enormous.

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[1] Malnutrition is associated with both undernutrition and overnutrition. In this report, the term refers to cases of *under*nutrition as measured by underweight rates. A child is considered underweight if the child falls below an anthropometric cut-off of –2 standard deviations below the median weight-for-age z-score of the National Center for Health Statistics/World Health Organization international reference.

Table 1—Trends in child malnutrition (underweight) in developing countries, by region, 1970–95

Region	Percent underweight							Number underweight						
	1970	1975	1980	1985	1990	1995	Change 1970–95	1970	1975	1980	1985	1990	1995	Change 1970–95
			(percent)				(percentage points)			(millions under age five)				(percentage points)
South Asia	72.3	67.7	63.7	61.1	53.4	49.3	–23.0	92.2	90.6	89.9	100.1	95.4	86.0	–6.2
Sub-Saharan Africa	35.0	31.4	28.9	29.9	28.8	31.1	–3.9	18.5	18.5	19.9	24.1	25.7	31.4	+12.9
East Asia	39.5	33.3	30.0	26.5	23.5	22.9	–16.6	77.6	45.1	43.3	42.8	42.5	38.2	–39.4
Near East and North Africa	20.7	19.8	17.2	15.1	n.a.	14.6	–6.1	5.9	5.2	5.0	5.0	n.a.	6.3	+0.4
Latin America and the Caribbean	21.0	17.0	12.2	10.6	11.4	9.5	–11.5	9.5	8.2	6.2	5.7	6.2	5.2	–4.3
All regions	46.5	41.6	37.8	36.1	32.3	31.0	–15.5	203.8	167.6	164.3	177.7	176.7	167.1	–36.7

Sources: 1975, 1980, and 1985 prevalences and numbers of malnourished children are from Table 1.2 of ACC/SCN 1992; 1990 and 1995 estimates are from WHO 1997, Table 6. Where the regions differ in these sources from the five listed, population estimates were used to make appropriate region-specific approximations. The 1970 figures are predicted using the underlying-determinant model regression results presented in Chapter 5 of this paper. The source for the population data used to calculate the numbers of underweight children for 1970 is United Nations (1996). Large jumps in numbers of underweight children between successive five-year periods (East Asia 1970 and 1975, for example) may be explained by the use of differing sources of population estimates.

Notes: A child under five (0–59 months) is considered malnourished if the child falls below an anthropometric cut-off of –2 standard deviations below the median weight-for-age z-score of the National Center for Health Statistics/World Health Organization international reference. n.a. means that data are not available.

While the number of malnourished children in the developing world has remained roughly constant, the prevalence of child malnutrition (or share of children who are malnourished) has been progressively declining (Table 1). It fell from 46.5 percent to 31 percent between 1970 and 1995, about 15 percentage points overall. This decline indicates that, although reducing child malnutrition to minimal levels remains a huge challenge, fairly substantial progress has been made over the last 25 years. The pace of progress has varied among the regions, however. Prevalences have fallen the fastest for South Asia (23 percentage points) and the slowest for Sub-Saharan Africa (4 percentage points). In recent years there has been a deceleration: whereas from 1970 to 1985 the developing-world prevalence fell by 0.8 percentage points per year, from 1985 to 1995 it fell by only 0.33. The situation is particularly troubling in Sub-Saharan Africa where the share of underweight children actually *increased* from 28.8 percent to 31.1 percent between 1990 and 1995. Since 1970, underweight rates decreased for 35 developing countries, held steady in 15, and increased for 12, with most of the latter countries being in Sub-Saharan Africa (WHO 1997).

Why have some countries and regions done better than others in combating child malnutrition? The overall objective of this study is to use historical cross-country data to answer this question. The study aims to improve our understanding of the relative importance of the various determinants of child malnutrition, both for the developing countries as a whole and for each individual region. In doing so, it also aims to contribute to the unraveling of some important puzzles currently under debate: (1) Why has child malnutrition been rising in Sub-Saharan Africa? (ACC/SCN 1997); (2) Why are child malnutrition rates in South Asia so much higher than those of Sub-Saharan Africa, that is, what explains the so-called "Asian enigma"? (Ramalingaswami, Johnson, and Rohde 1996; Osmani 1997); (3) How important a determinant of child malnutrition is food availability at a national level? (Smith et al. 1999; Haddad, Webb, and Slack 1997); (4) How important are women's status and education? (Quisumbing et al. 1995; Osmani 1997; Subbarao and Raney 1995); (5) How important are national political and socioeconomic factors (such as democracy and national incomes), and how do they affect child malnutrition? (Anand and Ravallion 1993; Pritchett and Summers 1996). It is hoped that answering these questions will contribute to the debate on how to make the best use of available resources to reduce child malnutrition in the developing countries as quickly as possible now and in the coming years.

The study employs the highest quality, nationally representative data on child underweight prevalences that are currently available for the period 1970–96 to undertake a cross-country regression analysis of the determinants of child malnutrition. The study differs from past cross-country regressions in four important ways. First, extreme care has been taken in assembling, cleaning, and documenting the data used. The quality of the data is obviously important to the credibility of the conclusions drawn. However, little attention has been paid to this issue outside of the World Health Organization's (WHO's) excellent *WHO Global Database on Child Growth and Malnutrition* (1997), from which most of the data in this study are drawn. Second, the econometric techniques employed are more rigorous than those used in most other studies. A number of specification tests are employed to establish the robustness of the results and the soundness of the specification and estimation procedures. Third, the study goes beyond the simple generation of elasticities to estimate the contribution of each nutrition determinant to reductions in child malnutrition over the past 25 years. Fourth, national food availability projections from the IFPRI IMPACT model (Rosegrant, Agcaoili-Sombilla, and Perez 1995), together with assumptions about future values of other determinants, are used to project levels of malnutrition in the year 2020 under pessimistic, optimistic, and status quo scenarios, and key policy priorities for each developing region are laid out.

The next chapter presents a conceptual framework for the determinants of child malnutrition. Chapter 3 reviews previous cross-national studies on health and nutrition. Chapters 4 and 5 present the data, methods, and estimation results of the study. Chapter 6 contains a retrospective analysis of how child malnutrition has been reduced over the last 25 years, and Chapter 7 contains projections of child malnutrition for the year 2020. Chapter 8 discusses regional policy priorities for reducing child malnutrition over the coming decades. The report concludes with a summary of its main findings, its limitations, and recommendations for future research.

CHAPTER 2

Conceptual Framework: The Determinants of Child Nutritional Status

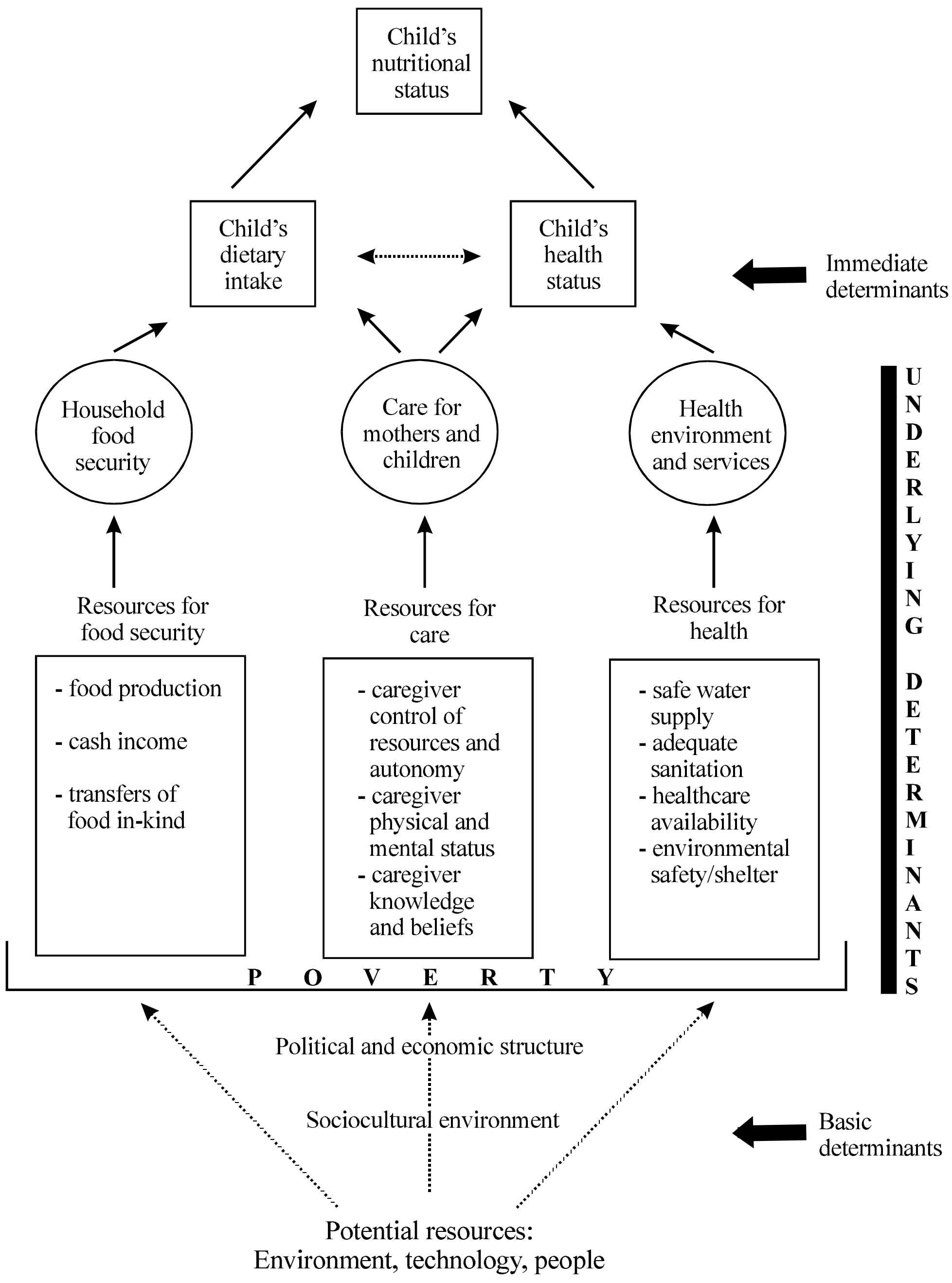
The conceptual framework underlying this study (Figure 1) is adapted from the United Nations Children's Fund's framework for the causes of child malnutrition (UNICEF 1990, 1998) and the subsequent extended model of care presented in Engle, Menon, and Haddad (1999). The framework is comprehensive, incorporating both biological and socioeconomic causes of malnutrition, and it encompasses causes at both the micro and macro levels. It recognizes three levels of causality corresponding to immediate, underlying, and basic determinants of child nutritional status.

The *immediate determinants* of child nutritional status manifest themselves at the level of the individual human being. They are dietary intake (energy, protein, fat, and micronutrients) and health status. These factors themselves are interdependent. A child with inadequate dietary intake is more susceptible to disease. In turn, disease depresses appetite, inhibits the absorption of nutrients in food, and competes for a child's energy. Dietary intake must be adequate in quantity and in quality, and nutrients must be consumed in appropriate combinations for the human body to be able to absorb them.

The immediate determinants of child nutritional status are, in turn, influenced by three *underlying determinants* manifesting themselves at the household level. These are food security, adequate care for mothers and children, and a proper health environment, including access to health services. Associated with each is a set of resources necessary for their achievement.

Food security is achieved when a person has access to enough food to lead an active and healthy life (World Bank 1986). The resources necessary for gaining access to food are food production, income for food purchases, or in-kind transfers of food (whether from other private citizens, national or foreign governments, or international institutions). No matter how much food is available, no child grows without nurturing from other human beings. This aspect of child nutrition is captured in the concept of care for children and their mothers, who give birth to children and who are commonly

Figure 1—Conceptual framework guiding empirical analysis



Sources: Adapted from UNICEF 1990, 1998; and Engle, Menon, and Haddad 1999.

their main caretakers after they are born. *Care*, the second underlying determinant, is the provision by households and communities of "time, attention, and support to meet the physical, mental, and social needs of the growing child and other household members" (ICN 1992). Examples of caring practices are child feeding, health-seeking behaviors, support and cognitive stimulation for children, and care and support for mothers during pregnancy and lactation. The adequacy of such care is determined by the caregiver's control of economic resources, autonomy in decisionmaking, and physical and mental status. All of these resources for care are influenced by the caretaker's status relative to other household members. A final resource for care is the caretaker's knowledge and beliefs. The third underlying determinant of child nutritional status, *health environment and services*, rests on the availability of safe water, sanitation, health care, and environmental safety, including shelter.

A key factor affecting all underlying determinants is poverty. A person is considered to be in absolute poverty when he or she is unable to satisfy adequately his or her basic needs—such as food, health, water, shelter, primary education, and community participation (Frankenberger 1996). The effects of poverty on child malnutrition are pervasive. Poor households and individuals are unable to achieve food security, have inadequate resources for care, and are not able to utilize (or contribute to the creation of) resources for health on a sustainable basis.

Finally, the underlying determinants of child nutrition (and poverty) are, in turn, influenced by *basic determinants*. The basic determinants include the potential resources available to a country or community, which are limited by the natural environment, access to technology, and the quality of human resources. Political, economic, cultural, and social factors affect the utilization of these potential resources and how they are translated into resources for food security, care, and health environments and services.

The conceptual framework of Figure 1 can be usefully placed in the context of a multimember household economic model. The household behaves as if maximizing a welfare function, W, made up of the utility functions of its members (U^i), indexed $i = 1, \dots, n$. The household members include a caregiver who is assumed to be the mother (indexed $i = M$), D other adults (indexed $i = 1, \dots, D$), and J children (indexed $i = 1, \dots, J$). The welfare function takes the form:

$$W(U_M, U_{ad}^1, \dots, U_{ad}^D, U_{ch}^1, \dots, U_{ch}^J; \beta) \text{ and } \beta = (\beta^M, \beta_{ad}^1, \dots, \beta_{ad}^D), \tag{1}$$

where the βs represent each adult household member's "status." Such status affects the relative weight placed on members' preferences in overall household decisionmaking, or their decisionmaking power. The utility functions take the form:

$$U^i = U(N, F, X_o, T_L) \quad i = 1, \dots, n = 1 + D + J. \tag{2}$$

where N, F, X_o and T_L are $1 \times N$ vectors of the nutritional status, food and nonfood consumption, and leisure time of each household member.

Nutritional status is viewed as a household provisioning process with inputs of food, nonfood commodities and services, and care. The nutrition provisioning function for child *i* is as follows:

$$N_{ch}^{i} = N(F^{i}, C^{i}, X_{N}^{i}; \xi^{i}, \Omega_{HEnv,}\ \Omega_{Food}, \Omega_{NEnv})\ i = 1, \ldots, J, \tag{3}$$

where C^{i} is the care received by the i^{th} child, and X_{N}^{i} represents nonfood commodities and services purchased for caregiving purposes, such as medicines and health services. The variable ξ^{i} serves as the physiological endowment of the child (his or her innate healthiness). The variable Ω_{HEnv} represents the health environment, that is, the availability of safe water, sanitation, and health services in the household's community. The variable Ω_{Food} represents the availability of food in the community. Finally, the variable Ω_{NEnv} represents the characteristics of the community's natural environment, such as agroclimatic potential, soil fertility, and water stress level.

The child's care, C^{i}, is itself treated as a child-specific, household-provisioned service with the time input of the child's mother, T_{c}^{i}. The mother's decisionmaking process in caregiving is assumed to be governed by the following functions:

$$C^{i} = C(T_{c}^{i}, N^{M}; E^{M}, \Omega_{c}) \quad i = 1, \ldots, J, \text{ and} \tag{4}$$

$$N^{M} = N(F^{M}, C^{M}, X_{N}^{M}; \xi^{M}, \Omega_{HEnv,}\ \Omega_{Food}, \Omega_{NEnv}, \beta). \tag{5}$$

In equation (4) E^{M} is the mother's educational level (assumed to be contemporaneously exogenous), which affects her knowledge and beliefs. The term Ω_{c} represents cultural factors affecting caring practices. N^{M} is the mother's own nutritional status, embodying the status of her physical and mental health. In addition to the variables entering into the child nutrition provisioning function, the mother's nutritional status may be determined by β, embodying her status relative to other adult members. In this context, the variable reflects the relative value placed on the mother's well-being both by other household members and herself, the latter as reflected in her self-esteem.

The maximization of (1) subject to (2), (3), (4), and (5) along with household members' time and income constraints leads to the following reduced-form equation for the i^{th} child's nutritional status in any given year:

$$N_{ch}^{i*} = (\beta, \xi^{1}, \ldots \xi^{J},\ \xi^{M}, \Omega_{HEnv,}\ \Omega_{Food}, \Omega_{NEnv}, \Omega_{c}, E^{M}, P, I)\ \ i = 1, \ldots, J, \tag{6}$$

where P is a vector of prices of X_0, X_N, F, and I is the household's total (exogenous) income.

Equation (6), a representation of household and individual behavior, can be used to identify variables at the national level that are important determinants of children's nutritional status. These are women's relative status (β), health environment (Ω_{HEnv}), food availability (Ω_{Food}), characteristics of countries' natural environments (Ω_{NEnv}), cultural norms affecting caring practices (θ_{c}), women's education (E^{M}) and real household and national incomes (represented by I and P).

CHAPTER 3

Review of Past Cross-Country Studies

A number of cross-country studies of the determinants of child malnutrition and related health outcomes have been carried out over the last five years. In this chapter, three that address the determinants of health (an immediate determinant) and six that directly address child malnutrition are reviewed. The goal is to give a broad overview of these studies' findings on the causes of child malnutrition and to identify limitations that can be overcome in the present analysis. The studies and their findings are summarized in the Appendix, Tables 22 and 23. Before moving on, it is useful to consider the merits and demerits of cross-country studies.

General Issues Concerning Cross-Country Studies

Cross-country studies are a useful complement to within-country case studies mainly because they exploit the fact that some variables that might be important determinants of child nutrition, such as democracy and women's status, may vary more between countries than within them. Other variables may only be observed at a national level, for example, national food supplies and incomes. In addition, the use of cross-country data for multivariate analysis identifies weaknesses in data series that might not be identified through the casual observation of trends and two-way tables, thus generating a demand for improvement in data quality. Finally, cross-country analysis can provide a basis for establishing policy priorities on a regional and global basis.

Several concerns regarding cross-country studies have been raised.[2] First, the quality and comparability of the data themselves have been questioned. Data on dif-

[2] Many of the concerns expressed about cross-country studies are concerns that will plague any study employing cross-sectional data. These include: (1) the lack of a theory that is specific enough to determine which variables belong in the regression equation (Sala-I-Martin 1997), (2) general problems with making inferences from cross-section data in that the counterfactual is never observed (Przeworski and Limongi 1993), and (3) the diminished ability to control for confounding variables (Pritchett and Summers 1996). Fortunately, in the area of malnutrition good conceptual models are available to minimize problems related to model specification. In addition, econometric techniques—the techniques used in this study—are available to account for problems of confounding variables. The issue of drawing inferences from cross-sectional data is a profound one and is a limitation that the authors of this report, along with all other researchers who use cross-sectional data, have to acknowledge and respect.

ferent variables may come from different agencies, each of which has its own quality standard and sampling frame. Moreover, variable definitions may not be uniform across countries. For example, the definition of "access to safe water" may be different between Egypt and Ghana. A second concern is that data availability problems are more pronounced at the national level than they are for household-level analysis. Studies must often employ available data as proxies for variables for which one would like to employ a more direct measure.

A third concern regarding cross-country studies relates to their subnational applicability. Child malnutrition is inherently an individual and household-level phenomenon. Can cross-country data be used to make inferences about household and individual behavior? An implicit assumption is that a country represents a "representative citizen." But the use of average data can be misleading if distribution is important and differs across countries (Behrman and Deolalikar 1988). Similarly, results arrived at through the use of cross-national data may not be applicable to individual countries' situations, yet it is at the country (and subnational) levels that many policy decisions are made. That all countries are given equal weight in a cross-country regression analysis may exacerbate this policy, yet many countries' populations are hundreds of times smaller than, for instance, China's and have populations that vary widely in their characteristics and behaviors.

Finally, some variables that are exogenous at a household level must be treated as endogenous at the national level since they reflect choices of national policymakers. Therefore, addressing endogeneity concerns is particularly crucial in cross-national studies (Behrman and Deolalikar 1988). Because of the scarcity of data, however, it is particularly difficult to do so and often not done.

The quality of the data employed in this study is discussed in Chapter 4. Care has been taken to use only the best data available to construct variables that as far as possible measure the key variables in the conceptual framework. In Chapter 4 the issue of using different regression weights for countries based on their population size is also discussed, as well as the steps taken to address endogeneity issues. Concerning subnational applicability, it can only be said that cross-country studies, while often based on aggregated household-level data, are intended to capture broad global and (for some studies) regional trends. Readers must keep in mind that at the household level there may be wide variation within countries; policies and programs targeted at a subnational level will have to be formulated with these differences in mind. The same can be said of the concern about the applicability of the results to individual countries.

Past Studies of the Determinants of Health and Child Malnutrition

The main determinants examined in the cross-country health determinants literature are national incomes, poverty, education, and the state of countries' health environments, including the availability of health services. The outcome variables of interest are measures of life expectancy and premature mortality.

In a 1993 journal article, Anand and Ravallion seek to answer the question of how health is affected by per capita national income levels, poverty, and the public provision of social services. National income is measured as gross domestic product (GDP) per capita, and poverty as the proportion of a country's population consuming less than one dollar a day. Both measures are reported in U.S. dollars arrived at through exchange rates adjusted to purchasing power parity (PPP) to improve cross-country comparability. The public provision of social services is measured as public health spending per capita. The authors find a strong simple correlation between national income and life expectancy for 86 developing countries in 1985. Using ordinary least squares (OLS) regression techniques for a subsample of 22 countries for which they have comparable data, they add poverty incidence and public health spending per person as explanatory variables. They find that the significant, positive relationship between life expectancy and national income vanishes entirely once poverty and public health spending are controlled for. Poverty has a significant negative effect on life expectancy; public health spending has a significant positive effect. A similar result is found by the authors for infant mortality. The authors conclude that "average income matters, but only insofar as it reduces poverty and finances key social services" (Anand and Ravallion 1993, 144).[3] They find that one-third of national incomes' effect on life expectancy is through poverty reduction and two-thirds through increased public health spending.

Subbarao and Raney (1995) focus on the role of female education using a sample of 72 developing countries and data over the period 1970 to 1985. Using OLS regression, they regress infant mortality rates in 1985 on female and male gross secondary school enrollment ratios lagged 5 and 10 years, GDP per capita (PPP-adjusted), rates of urbanization, a family planning services score,[4] and a proxy variable for health service availability, population per physician. They find that female education has a very strong influence on infant mortality rates. Per capita national income, family planning services, and population per physician are statistically significant, but are not as powerful as female education. The authors estimate that, for a typical poor country, a doubling of female education in 1975 would have reduced infant mortality rates in 1985 from 105 to 78. In comparison, halving the number of people per physician would have reduced it by only 4 points (from 85 to 81) and a doubling of national income per capita would have lowered it by only 3 (from 102 to 99).

Neither of these two studies test for the possibility that a country's income itself may be affected by the health of its citizens. The OLS regression technique employed also does not account for any omitted country-specific effects that may influence health outcomes and be correlated with the explanatory variables included. They thus risk identifying a merely associative rather than causative relationship between the dependent and explanatory variables of interest.

[3] In a later study, Bidani and Ravallion (1997) use data on 35 developing countries to estimate a random coefficients model of life expectancy and infant/perinatal mortality rates on the distribution of income (breaking countries' populations into groups of "poor" and "nonpoor"), public health spending, and primary schooling. They find poverty to be an important determinant of health and they find that public health spending and primary school enrollment matter, but more for the poor than the nonpoor.

[4] This score is based on several factors including community-based distribution of family planning services, social marketing, and number of home-visiting workers.

Pritchett and Summers (1996) take the income question a step further by applying econometric techniques that detect and account for any possible spurious association or reverse causation between health and income.[5] Using data from 1960 to 1985 for between 58 and 111 countries (depending on the estimation technique employed), they examine the impact of GDP per capita ($PPP) and education levels on infant mortality, child mortality, and life expectancy. They eliminate possibly spurious correlation by controlling for country-specific, time-invariant factors (such as climate and culture) using a first-difference approach. They control for possible reverse causation between income and the outcome variables by employing instrumental variables techniques, using a variety of instruments for income, for example, countries' terms-of-trade and investment rates. For all regressions the authors find a significant and negative impact of income on infant mortality. The results are similar for other dependent variables such as child mortality rates, but weaker for life expectancy. They conclude that "increases in a country's income will tend to raise health status" (p. 865), estimating a short-run (5-year) income elasticity of –0.2 and a long-run (30-year) income elasticity of –0.4. Education was also found to be a significant factor in improving health status.

Most of the explanatory variables considered in cross-national studies of child malnutrition are the same as for health outcome studies: per capita national incomes, female education, and variables proxying for health service provisioning. Almost all studies also include food available for human consumption as an explanatory variable, measured as daily per capita dietary energy supply (DES) derived from food balance sheets. The dependent or outcome variables employed are the prevalence of underweight or stunted children under age five.[6]

A study undertaken by the United Nations Administrative Committee on Coordination's Sub-Committee on Nutrition (ACC/SCN) (1993) examines the determinants of underweight prevalence for 66 developing countries from 1975 to 1992.[7] The study includes several countries for which data are available for more than one point in time, giving a total number of observations of 100. Applying OLS regression, it finds that DES (especially for South Asia), female secondary school enrollment, and government expenditures on social services (health, education, and social security) are all negatively and significantly associated with underweight prevalence. Regional effects, accounted for by using dummy variables, are found to be statistically significant and especially large for South Asia. This suggests that factors specific to South Asia that are not accounted for in the analysis are partly responsible for its high prevalence of malnutrition.

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[5] Reverse causation between two variables means that the first variable affects the second and the second in turn affects the first.

[6] A child under age five is considered stunted if the child falls below an anthropometric cut-off of –2 standard deviations below the median height-for-age Z-score of the United States' National Center for Health Statistics/World Health Organization international reference.

[7] Note that this study was undertaken with the primary aim of developing an estimating equation with the best predictive value. Nevertheless, the estimation results identify variables, some of which may be causal factors, that are statistically associated with child underweight rates.

A 1994 ACC/SCN update focuses specifically on the role of per capita income growth in determining annual changes in underweight prevalences for 42 developing countries from 1975 to 1993. The study finds a statistically significant relationship between GDP per capita growth and changes in underweight prevalence,[8] with a one point increase in the growth rate of the former leading in general to a 0.24 percentage point decrease in the underweight prevalence annually. Given an average annual reduction in the underweight prevalence rate during the study period (estimated from the reported regional averages) of 1.5, this is a fairly large effect. The study concludes, however, that "although economic growth is a likely factor in nutritional improvement, the deviation from the rate expected is substantial and important" (p. 4), suggesting that other factors are important as well. Gillespie, Mason, and Martorell (1996) extend the ACC/SCN analysis to include consideration of a role for public expenditures on social services and food availabilities. Using a subset of 35 countries in the original data set, they find that *levels* of public health and education expenditures (measured as a share of total government budgets) are significant determinants of changes in underweight prevalences, but that both levels and changes in food availability are not.[9]

Rosegrant, Agcaoili-Sombilla, and Perez (1995)[10] use data from 61 developing countries to regress underweight prevalences on DES, percentage of public expenditures devoted to social services (health, education, and social security), female secondary education, and as a proxy for sanitation, the percentage of countries' populations with access to safe water. The data employed are predicted underweight rates for 1980, 1985, and 1990 generated by the ACC/SCN (1993) study. The data over these time periods were pooled and OLS regression techniques were applied. The study found DES and social expenditures to be significantly (negatively) associated with underweight rates, but female education and access to safe water were statistically insignificant determinants.

Osmani (1997) attempts to explain the "South Asian puzzle," that is, why South Asia's child malnutrition rate is so much higher than Sub-Saharan Africa's, despite almost equal poverty rates, higher food availability in South Asia, and comparable levels of public provision of health and sanitation services. The study employs OLS regression to explore the determinants of child stunting for 66 developing countries in the early 1990s. The initial explanatory variables are per capita GDP ($PPP), health services (proxied by population per physician), extent of urbanization, and the female literacy rate. All are found to be important determinants of stunting. A South Asian dummy variable is significant and quite large, indicating (as does ACC/SCN 1993) that additional

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[8] It is not clear whether the GDP growth rates utilized are estimated using PPP-adjusted exchange rates or using data generated by the traditional World Bank atlas method.

[9] Note that the "quasi" first differences approach, in which the dependent variable is expressed in changes over time but some or all of the independent variables are not, does not account for country-specific (time invariant) factors as would a pure first differences approach.

[10] The estimations in this study were also undertaken with the primary aim of developing an estimating equation with the best predictive value rather than identifying causal relationships.

factors explain South Asia's extreme rates of child stunting. Under the hypothesis that the presence of relatively high rates of low birth weight are at the root of the South Asian puzzle, this variable is added into a second estimating equation, causing the South Asian dummy variable to lose its significance. In a third estimating equation the dummy variable is dropped and replaced with the low birth weight variable. The latter is statistically insignificant in this equation. The author concludes that low birth weight and factors influencing it—particularly the low status of women in South Asia—are important determinants of stunting. However, since low birth weight is endogenous (it is partially determined itself by both per capita income and female literacy), the OLS coefficient estimates are likely to be biased, weakening the study's conclusions.

Frongillo, de Onis, and Hanson (1997) examine the determinants of child stunting using data from 70 developing countries in the 1980s and 1990s. They find national income per capita,[11] DES, government health expenditures, access to safe water, and female literacy rates all to be statistically significant factors. In addition to these variables, the study tests for the significance of four others representing countries' socioeconomic and demographic structure: proportions of population that are urban, proportions of population in the military, population density, and female share of the labor force. It finds none of these variables to be significant determinants of stunting. As for previous studies, regional effects are found to be strong and significant. They are particularly strong for the "Asia" region, which is represented by 17 countries from South Asia, East Asia, and the Near East.

In conclusion, while suffering from some methodological limitations, the studies reviewed above point to the importance of four key variables as determinants of child malnutrition. These are per capita national incomes, women's education, variables related to health services and the healthiness of the environment, and national food availability. They present conflicting results, however, with respect to women's education, health environments, and food availability. Anand and Ravallion (1993) and Osmani (1997) suggest that, in addition, poverty and variables affecting birth weight, such as women's status, may be key. The studies also point to the importance of accounting for potential differences across regions, most particularly, that the determinants for South Asia may be different than those for the other regions.

Methodological Limitations of Past Cross-Country Studies

From a conceptual standpoint, most studies have not taken into account the differing pathways through which the various determinants of child malnutrition influence it. The danger of not doing so is illustrated in the study by Anand and Ravallion (1993). The analysis shows that income affects health mainly through its influence on government expenditures on social services and poverty. When both income and other variables that income determines are included in the health regression equation, the parameter estimate for income drops substantially in magnitude. This downward bias

[11] The paper does not specify whether GDP is measured using PPP-adjusted exchange rates.

results not because income is not important, but because its effect is already picked up by the variables it determines. Past studies that have mixed basic, underlying, and immediate determinants in the same regression equation for child malnutrition[12] have probably underestimated the strength of impact and statistical significance of determinants lying at broader levels of causality.

The studies reviewed here (with the exception of Pritchett and Summers 1996) also have not addressed the important issue of endogeneity, in particular, correlation between the error term and included explanatory variables. Endogeneity can arise from a number of different sources. The first, mentioned earlier, is the presence of reverse causality between child malnutrition and one of the explanatory variables. For example, programs to improve health infrastructure may be targeted to countries with high child malnutrition (the problem of endogenous program placement). The second is the omission of important determinants of child malnutrition (whose effects are relegated to the error term) that may be correlated with the included explanatory variables. Cultural factors influencing caring behaviors, for example, are difficult to measure and are typically unobserved, but are important to nutritional outcomes. Their exclusion can cause widespread omitted variables bias because they may be correlated with included variables like female education (Engle, Menon, and Haddad 1999). The third is the simultaneous determination of child malnutrition and one of the explanatory variables by some third unobserved variable. For example, restrictions on female labor force participation (unobserved) might reinforce women's low status (a potential determinant of child malnutrition) and simultaneously affect child malnutrition through lack of income earned by women. A final source of endogeneity is measurement error in the explanatory variables. If any of these four problems exists, OLS parameter estimates will be biased, leading to inaccuracy in the estimates and error in inferences based on them.

[12] See Behrman and Deolalikar 1988 for further discussion of the use of "quasi reduced-form estimating equations in analysis of the determinants of health and nutrition."

CHAPTER 4

Data and Estimation Strategy

Explanatory Variables Employed

This report focuses on the underlying and basic determinants of child malnutrition. It addresses the role of explanatory variables that represent all three of the underlying determinants described in the conceptual framework: food security, care, and health environments, as well as the role of two variables representing the basic economic and political determinants of child malnutrition. How past child malnutrition influences current levels is also considered. The choice of variables, described in this chapter, is guided by the conceptual framework (Figure 1), experience gleaned from past studies, and data availability. Poverty is excluded from the analysis due to scarcity of data.[13]

Underlying Determinant Variables

Unfortunately no cross-national data on *food security* from nationally representative household survey data are available. However, data do exist for one of its main determinants: *national food availability.* This variable is used as a proxy, although it does not fully account for the important problem of food access, which is also essential for the achievement of food security (Sen 1981; Smith et al. 1999).

Similarly, because no cross-national measures of *maternal and child care* that cover the time span of the study exist, *women's education* and *women's status relative to men's* are used as proxies for this determinant. The education level of women—the main caretakers of children—has several potentially positive effects on the quality of care. More educated women are better able to process information, acquire skills, and model positive caring behaviors. More educated women tend to be better able to use health care facilities, to interact effectively with health care providers, to comply with

[13] Recent, internationally comparable poverty data are available for only 41 of the 63 countries in the study sample (World Bank 1998b). Further, data for more than one point in time are not always available (Ravallion and Chen 1997).

treatment recommendations, and to keep their living environment clean. More educated women tend to be more committed to child care and to interact with and stimulate their children more. Finally, education increases women's ability to earn income, but this increases the opportunity cost of their time, which may mitigate against some important caregiving behaviors, for example, breast feeding (Engle, Menon, and Haddad 1999).

Regarding women's status, low status restricts women's opportunities and freedoms, reduces their interaction with others and their opportunity for independent behavior, restricts the transmission of new knowledge, and damages self-esteem and expression (Engle, Menon, and Haddad 1999). Status is a particularly important determinant of two resources for care: mothers' physical and mental health and their autonomy and control over resources in households. The physical condition of women is closely associated with the quality of the care they give, starting even before a child is born. A woman's nutritional status in childhood, adolescence, and pregnancy has a strong influence on her child's birth weight and subsequent growth (Martorell et al. 1998; Ramakrishnan, Manjrekar et al. 1999). A woman who is in poor physical and mental health provides lower quality care to her children after they are born, including the quality of breast feeding. In general, when the care of a child's mother suffers, the child's care suffers as well (Ramalingaswami, Johnson, and Rohde 1996; Engle, Menon, and Haddad 1999). While women are more likely to allocate marginal resources to their children than are men, the less autonomy and control over resources they have, the less able they are to do so (Haddad, Hoddinott, and Alderman 1997; Smith and Chavas 1997). In short, low status restricts women's capacity to act in their own and their children's best interests. Much work indicates that it is women's status relative to men's that is the important factor, especially for resource control in households (Haddad, Hoddinott, and Alderman 1997; Smith 1998b; Kishor and Neitzel 1996). Therefore, women's status *relative* to men's was chosen as the explanatory variable.

Note that women's education and relative status also play a key role in household food security. In many countries women are highly involved in food production and acquisition. The household decisions made in these areas are influenced by women's knowledge regarding the nutritional benefits of different foods and their ability to direct household resources toward food for home consumption (Quisumbing et al. 1995). Thus the effect of women's education and relative status on child malnutrition will partially reflect influences on food security as well as mother and child care.

For *health environment and services*, *access to safe water* is chosen as an explanatory variable. Improving water quantity and quality reduces the incidence of various illnesses, including diarrhea, ascariasis (roundworm), dracunculiasis (guinea worm), schistosomiasis, and trachoma (Hoddinott 1997). This variable was chosen as a proxy for health environment and services because it is the variable for which the most data are available and because the measure used here is highly correlated with other measures of the quality of a country's health environment and services (see below).

Basic Determinant Variables

To capture broadly the economic resource availabilities of countries, *per capita national income* is employed as an explanatory variable. National income is expected to play a facilitating role in all of the underlying-determinant factors laid out above. It may enhance countries' health environments and services as well as women's education by increasing government budgets. It may boost national food availability by improving resources available for purchasing food on international markets, and, for countries with large agricultural sectors, it reflects the contribution of food production to overall income generated by households. It may improve women's relative status directly by freeing up resources for improving women's lives as well as men's. Finally, there is a strong negative relationship between national incomes and poverty, as shown by a plethora of recent studies (see, for example, Ravallion and Chen 1997; Roemer and Gugerty 1997).

To account for the political context within which child malnutrition is determined, *democracy* is used as an explanatory variable. As for national income, democracy is hypothesized to play a facilitating role in all of the underlying-determinant factors considered. The more democratic a government, the greater the percentage of government revenues that may be spent on education, health services, and income redistribution. A more democratic government may also be more likely to respond to the needs of *all* of its citizens, women's as well as men's, indirectly promoting women's relative status. With respect to food security, the work of Drèze and Sen (1989) and others clearly points to the probable importance of democracy in averting famine. More democratic governments may be more likely to honor human rights—including the rights to food and nutrition (Haddad and Oshaug 1998)—and to encourage community participation (Isham, Narayan, and Pritchett 1995), both of which may be important means for reducing child malnutrition.

The estimation technique used only allows explicit consideration of observed variables that change over time. However, unobserved time-invariant factors that affect child malnutrition can be controlled for using econometric techniques. Some important determinants of child malnutrition identified in the last section fall into the latter category, for example, climate and sociocultural environments.

Past Child Malnutrition

It is well established that a child's current nutritional status is conditioned by the child's preceding nutritional status. In addition, malnutrition in childhood is known to have important long-term effects on the work capacity and intellectual performance of adults, who are the caretakers of children (Martorell 1997). Recent studies have also pointed to an intergenerational effect of child malnutrition, which shows that women who were malnourished as children are more likely to give birth to low birth-weight children who are thus more likely to be malnourished themselves (Ramakrishnan et al. 1999). At a country level, therefore, past prevalences of child malnutrition—regardless of current environmental factors—are likely to have an independent, numerically positive effect on current prevalences. They are thus included as an explanatory variable in an extension of the main analysis.

The Data and Operational Measures of Variables

The analysis in this report is based on data for 63 developing countries over the period 1970–96. The dependent variable is prevalence of children under age five who are underweight for their age. The availability of high-quality, nationally representative child underweight survey data is the limiting factor for inclusion of countries. Data for the explanatory variables are matched for each country by the year in which the underweight data are available. For statistical reasons (see the next section), only countries for which child malnutrition data are available for at least two points in time are included. The total number of country-year observations is 179.

The countries covered, classified by region, are listed in Table 2. For each country, the years covered are given in parentheses. The average number of observations per country is 2.8. The average number of years between observations for a country is 6.9. More than half of the countries in South Asia, Sub-Saharan Africa, East Asia, and Latin America and the Caribbean are included in the sample. The Near East and North Africa region, for which only 5 of 20 countries are included, has the poorest coverage (see the Appendix, Table 24 for a list of the regional grouping of developing countries). Overall, the sample covers 57 percent of the developing countries and 88 percent of the 1995 population of the developing world. While the data have not been purposefully sampled in a random manner, they are believed by the authors to adequately represent the population of developing countries.[14]

The data are compiled from various secondary sources. The measures for the explanatory variables, their definitions, and sample summary statistics are given in Table 3. In this section, a brief description is given for each. All numbers in the data set and their sources as documented by variable, country, and year are provided in a Data and Sources Supplement, available on the web at <www.cgiar.org/ifpri/pubs/abstract/111/rr111apx.xls> (which is a Microsoft Excel file) or in hard copy by request. The construction of a complete data set (containing no missing values) and full use of the available data necessitated estimation of values for a small number of observations on the explanatory variables (2 percent) using first-order regression techniques (Haddad et al. 1995).

[14] It is possible that countries with low rates of child malnutrition and high incomes are better able to conduct national surveys of malnutrition. In this case these countries would be overrepresented in the sample. However, it is equally likely that national-level malnutrition surveys are carried out in low-income countries with high rates of malnutrition due to the increased interest in them by institutions with external funding sources. Note that for four countries, Ethiopia, India, Kenya, and Nepal, child malnutrition rates are available only for the rural population. Corresponding data on the explanatory variables employed in the analysis are from nationally representative samples.

Table 2—Regional, country, and population coverage of the study

Region	Number of countries	Share of countries covered[a]	Share of population covered[b]	Number of observations	Country (years in parentheses)
		(percent)			
South Asia	5	71	98	16	Bangladesh (82, 85, 89, 96), India-rural (77, 91), Nepal-rural (75, 95), Pakistan (77, 85, 90, 95), Sri Lanka (77, 80, 87, 93).
Sub-Saharan Africa	26	58	83	65	Benin (87, 96); Burkina Faso (87, 92); Cameroon (77, 91); Comoros (91, 95); Congo, Republic of (77, 87); Congo, Democratic Republic of (75, 86, 89, 94); Côte d'Ivoire (86, 94); Ethiopia-rural (83, 92); Ghana (87, 93); Guinea (80, 95); Kenya-rural (82, 87); Lesotho (76, 81, 94); Madagascar (83, 92, 95); Malawi (81, 92, 95); Mauritania (81, 87, 90); Mauritius (85, 95); Niger (85, 92); Nigeria (90, 93); Rwanda (76, 92); Senegal (86, 92); Sierra Leone (74, 77, 90); Tanzania (87, 91, 96); Togo (76, 88); Uganda (77, 88, 95); Zambia (72, 85, 88, 92, 96); Zimbabwe (84, 88, 94).
East Asia	8	57	94	26	China (87, 92, 95), Indonesia (78, 87, 95), Laos (84, 94), Malaysia (83, 86, 90, 95), Myanmar (80, 83, 90, 95), Philippines (73, 82, 87, 93), Thailand (82, 87, 90), Viet Nam (80, 87, 94).
Near East and North Africa	5	31	37	14	Algeria (87, 92, 95), Egypt (78, 88, 92, 95), Jordan (75, 90), Morocco (87, 92), Tunisia (74, 88, 94).
Latin America and the Caribbean	19	68	85	58	Bolivia (81, 89, 93), Brazil (75, 89, 96), Chile (78, 82, 86, 95), Columbia (77, 86, 89, 95), Costa Rica (78, 82, 89, 94), Dominican Republic (86, 91), El Salvador (88, 93), Guatemala (77, 80, 87, 95), Guyana (71, 81, 93), Haiti (78, 90, 94), Honduras (82, 87, 93), Jamaica (78, 85, 89, 93), Mexico-rural (74, 79, 89), Nicaragua (80, 93), Panama (80, 92), Peru (75, 84, 91, 96), Trinidad and Tobago (76, 87), Uruguay (87, 92), Venezuela (81, 87, 90, 94).
Total	63	57 percent of the developing countries	88 percent of the developing-country population	179	

Source: Population data, United Nations 1998.

[a] See Appendix 1, Table 24 for a regional grouping of the developing countries.

[b] These percentages are calculated from countries' 1995 populations.

Table 3—Variable definitions and sample summary statistics

Variable	Definition	Mean	Standard deviation	Minimum	Maximum
Prevalence of child malnutrition (*CHMAL*)	Percent of children under five less than –2 standard deviations below the median weight-for-age Z-score of the NCHS/WHO international reference	24.6	15	0.9 (Chile 1995)	71.3 (India 1977)
Access to safe water (*SAFEW*)	Percent of population with access to safe water (percent)	56.2	23.7	6 (Ethiopia 1983)	100 (Mauritius 1985)
Female secondary school enrollment (*FEMSED*)	Gross female secondary school enrollment rate (percent)	33.8	22.5	2.5 (Uganda 1977)	88 (Uruguay 1992)
Female-to-male life expectancy ratio (*LFEXPRAT*)	Ratio of female life expectancy at birth to male life expectancy at birth	1.062	0.03	0.97 (Nepal 1975)	1.15 (El Salvador 1988)
Per capita dietary energy supply (*DES*)	Daily per-capita dietary energy supply (kilocalories)	2,360	331	1,592 (Ethiopia 1992)	3,284 (Egypt 1995)
Per capita GDP (*GDP*)	Per capita gross domestic product (in purchasing power parity—adjusted 1987 U.S. dollars)	2,306	1,779	306 (Ethiopia 1992)	8,612 (Chile 1995)
Democracy (*DEMOC*)	Combined index of political rights and civil liberties (measured on a scale of 1 to 7 points, 1 = least democratic)	3.5	1.7	1[a]	7 (Costa Rica 1978, 1982, 1989)

[a] The countries for which the democracy index number is 1 are: Algeria (1995), Benin (1987), China (1992, 1995), Ethiopia (1983), Guinea (1980), Haiti (1994), Laos (1994), Mauritania (1995), Myanmar (1990, 1995), Uganda (1977),Viet Nam (1980, 1987, and 1994), and Zaire (1986).

Child Malnutrition

For child malnutrition (CHMAL), a measure of the prevalence of underweight children under age five is employed. The criteria for identifying an underweight child is that the child's weight-for-age be more than two standard deviations below the median, based on the National Center for Health Statistics/World Health Organization (NCHS/WHO) international reference. This measure represents a synthesis of height-for-age (identifying long-term growth faltering or stunting) and weight-for-height (identifying acute growth disturbances or wasting).[15] Most of the data—75 percent—are from the World Health Organization's Global Database on Child Growth and Malnutrition (WHO 1997). These data have been subjected to strict quality control standards for inclusion in the database.

The criteria for inclusion of surveys in the WHO Global Database are

- a clearly defined population-based sampling frame, permitting inferences to be drawn about an entire population;
- a probabilistic sampling procedure involving at least 400 children;
- use of appropriate equipment and standard measurement techniques;
- presentation of data in the form of Z-scores in relation to the NCHS/WHO reference population (WHO 1997).

A second source of data, 17 percent, is from ACC/SCN (1992 and 1996), which is felt to be of adequate quality. A third source of data, 7 percent, is from *World Development Indicators* (World Bank 1997a), for which the quality of data is unsure based on earlier experiences using it. All of the data were tested for potentially erroneous values and, subsequently, several observations from the latter source were discarded.[16] Where data are reported for under-three-year-olds rather than under-five-year-olds (12 percent of the data points), the data were converted to under-five-year-old equivalents based on a technique employed in ACC/SCN (1993) (see the Data and Sources Supplement).

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[15] While in the past national-level data on stunting and wasting were more rare than data on underweight, they are becoming increasingly available and more widely employed as indicators of child malnutrition (see ACC/SCN 1997 for the first review of trends in stunting, for example). Future cross-country panel data studies of the causes of child malnutrition will be able to use both of the indicators, which are likely to have different determinants (Victora 1992; Frongillo, de Onis, and Hanson 1997).

[16] A DFFITS procedure was employed to detect observations with unusually large or small values for the dependent variable or for one of the explanatory variables. The DFFITS statistic is a standardized measure, calculated for each observation, of the effect of dropping the observation on the fitted value of the dependent variable (see Haddad et al. 1995). For each observation for which the DFFITS statistic was above an established threshold, all variables were checked thoroughly for possible error by examining how well they conformed with other data in nearby years and checking with alternative sources. As a result of this procedure, a number of countries were excluded from the sample including four countries for which at least one (of the two necessary) data points was from the World Bank (1997a)—Botswana, the Central African Republic, Iran, and Paraguay—as well as 1970 data points for Côte d'Ivoire and Nigeria. No original source was reported for these data, and their values could not be justified through comparison with other data or sources.

National Food Availability

For national food availability, daily per capita dietary energy supply (DES) for each country is used. This measure is derived from food balance sheets compiled by the Food and Agriculture Organization of the United Nations (FAO) from country-level data on the production and trade of food commodities. Given data on seed rates, wastage, stock changes, and other types of utilization of food commodities (such as animal feed), a supply account is prepared for each commodity in terms of the weight available for human consumption each year. Total energy availability is then estimated by converting the weights of each commodity into energy values and aggregating the energy values across commodities. The aggregate energy supply is then divided by the population size to arrive at per capita DES. The data employed were obtained from FAO's 1998 FAOSTAT database.

Women's Education

Female gross secondary school enrollment rates (*FEMSED*) are used as a proxy measure for women's education. The variable is defined as total female enrollment in secondary school education, regardless of age, expressed as a percentage of the population age group corresponding to national regulations for education at the secondary level. It is thus a measure of the current percent of secondary-school-aged females who have completed primary school and completed some secondary education. The data are from the United Nations Educational, Scientific and Cultural Organization's UNESCOSTAT database (UNESCO 1998).

Women's Relative Status

There is no agreed upon measure of "women's status." Most measures available in the literature are multiple-indicator indexes (for example, UNDP 1992; Kishor and Neitzel 1996; Mohiuddin 1996; Ahooja-Patel 1993), which are vulnerable to charges of arbitrariness in composition and aggregation method (Deaton 1997). As discussed earlier, women's status relative to men's rather than their absolute status was chosen as the explanatory variable. The measure employed is the ratio of female life expectancy at birth to male life expectancy at birth (*LFEXPRAT*). Life expectancy at birth is defined as the number of years a newborn infant would live if prevailing patterns of mortality at the time of his or her birth were to stay the same throughout his or her life.

A long life is universally valued, not only for its own sake, but also because it is a necessary requirement for carrying out a number of accomplishments (or "capabilities") that are positively valued by society (Sen 1998). Writes Sen, "Gender bias . . . is very hard to identify, since many of the discriminations are subtle and covert, and lie within the core of intimate family behavior." Comparisons of the mortality (the converse of life expectancy) of women and men can be used to "throw light on some of the coarsest aspects of gender-related inequality" (p. 10). Inequalities in life expectancy favoring males reflect discrimination against females (as infants, children, and adults), entrenched, long-term gender inequality, and, ultimately a lower status for women than for men. While the chosen measure has some drawbacks, the authors feel that it is a good proxy indicator of the cumulative investments in women relative to men throughout the human life cycle.[17] The source for the life expectancy data is *World Development Indicators* (World Bank 1998a).

Access to Safe Water

The percentage of countries' populations with access to safe water (*SAFEW*) is the measure used for this variable. It is defined as the population share with reasonable access to an adequate amount of water that is either treated surface water or water that is untreated but uncontaminated (such as from springs, sanitary wells, and protected boreholes). An adequate amount of water is the amount needed to satisfy metabolic, hygienic, and domestic requirements, usually about 20 liters per person per day (World Bank 1997b). *SAFEW* is used to proxy the broad dimensions of countries' health environments, including access to sanitation and health care (for which insufficient data exist) in that measures of these variables are highly correlated with it.[18] Countries with high access to safe water are likely to have good health environments and services overall. The data are from various issues of UNICEF's *State of the World's Children* and the World Health Organization (WHO 1996).

The measure of access to safe water is the one in this research that gives rise to the most concern regarding data quality. In particular, walking distance or time from household to water source is the principle criterion used for assessing safe water access, but the definition varies across countries (WHO 1996). This problem is partially

[17] Patterns of mortality and life expectancy are the outcomes of many factors, including malnutrition during childhood, chronic diseases (both diet related and nondiet related), wars, HIV/AIDS, and childbirth for instance. These events are based, to a large extent, on human behavior and choices. The chosen measure—the ratio of female life expectancy to male life expectancy—is not a perfect measure of gender status differentials. For example, a decrease in male status cannot be claimed simply because men take up smoking at a faster rate than women. However, in line with Sen, a measure of gender inequality should capture the "coarsest forms of gender-related inequality." If male life expectancy were to decrease relative to female life expectancy for a reason related to gender-specific access to food and care, the validity of the measure in terms of its implications for child nutrition would hold, all else being equal. Despite its imperfections, the measure is the most complete available for the countries and years for which child malnutrition data are available. Even if more complete data were available for other potential cross-country proxy indicators (which they are not), they also have problems in terms of (1) definitions (for example, with the female share of the formal employment sector, it is notoriously difficult to get standardized definitions of "formal sector," and it is difficult to ascertain true formal labor force participation of women due to cultural and other invisible barriers to entry), and (2) cross-country validity (for example, measures comparing female and male education rates do not account for cross-country differences in educational quality for girls and boys). Note that for the countries and years in our sample for which another proxy measure of women's relative status is available—the ratio of female to male secondary school enrollment—the Pearson correlation coefficient with the female-to-male life expectancy ratio is 0.454 (p=.000).

[18] The Pearson's correlation coefficient between *SAFEW* and the measure "population with access to sanitation" is 0.63 (p=.000, with 114 observations). That between *SAFEW* and the measure "population with access to health care" is 0.59 (p=.000, with 92 observations). The widely reported measure "population per physician" is not used because the authors do not believe that this variable reflects the quality of health environments of the types of poor households likely to have malnourished children living in them.

accounted for in the regression estimations by controlling for country-specific attributes (see the next section). Care has also been taken to detect and investigate outliers for the variable and to construct tests for measurement error.

Per Capita National Income

For per capita national income, real per capita GDP is the measure used, expressed in PPP-comparable 1987 U.S. dollars. GDP in local currencies is converted to international dollars using PPP exchange rates so that the final numbers take into account the local prices of goods and services that are not traded internationally. The data are from the World Bank's *World Development Indicators* (World Bank 1998a).[19]

Democracy

For degree of democracy (*DEMOC*) an average of two seven-point country-level indexes from Freedom House (1997) are used, one of political rights and one of civil liberties, giving each an equal weight. Political rights enable people to participate freely in the political process and to choose their leader freely from among competing groups and individuals. Civil liberties give people the freedom to act outside of the control of their government, to develop views, institutions, and personal autonomy (Ryan 1995). The combined index ranges from 1 to 7, with "1" corresponding to least democratic and "7" to most.

Estimation Strategy

The dependent variable, child malnutrition (*CM*), is hypothesized to be determined by K explanatory variables, denoted X and indexed by $k = 1, \dots K$. It is assumed that the basic model relating these variables takes the form:

$$CM_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,it} + u_{it}; \quad i = 1, \dots, n; t = 1, \dots, T, \tag{7}$$

where i denotes countries, t denotes time, α is a scalar, β is a $K \times 1$ vector of parameters, and u_{it} is an error term. For expository purposes, it is assumed that all countries' observations are for the same time periods—that the panel is "balanced."

Equation (7) is estimated by OLS. In this case, all of the observations on individual countries and time periods are pooled. The error term u_{it} is assumed to be stochastic and normally distributed with mean zero and constant variance σ^2. The estimating equation is

[19] These data are only reported from 1980 to the present. To arrive at comparable PPP GDP per capita figures for the 1970s, it was necessary to impute growth rates from the data series on GDP in constant local currency units and apply them to countries' 1987 PPP GDPs.

$$CM_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,it} + u_{it},\, u_{it} \sim N(0, \sigma^2). \tag{8}$$

With the availability of data at more than one point in time for each country, the opportunity exists to control for unobserved heterogeneity across countries in the form of country-specific, time-invariant factors influencing child malnutrition. To do so, an "error components" model (Baltaji 1995) is used. Specifically, this model allows controls of country-specific factors that do not trend upward or downward over 13-year periods, the average time interval covered for a country in the sample. The factors may be climate, characteristics of countries' physical environments (such as soil type and topography), or deeply embedded cultural and social mores. The model also allows control of measurement errors and noncomparabilities in the data that arise from definitional and measurement differences at the country level (Ravallion and Chen 1997).

Error components models can be divided into two types, fixed effects (FE) and random effects (RE). In the RE approach, unobserved heterogeneity is considered to be random error, with the expected value of each country's error having a mean of zero. An important assumption is that this error is uncorrelated with the other regressors. In the FE approach, unobserved heterogeneity is considered to be fixed and different for each country (Hsiao 1996). According to Balestra (1996), "The question of knowing whether an effect is fixed or random is extremely delicate. . ." (p. 30). There appear to be no clear rules guiding the choice.[20]

Solely for statistical considerations, the choice between the FE and RE formulations involves a trade-off between consistency and reliability. The FE approach sacrifices degrees of freedom in order to attain consistency because an effect is estimated for each individual country. While the RE approach will yield inconsistent parameter estimates if correlation between the country-specific effects and the regressors exists, it is more efficient.

Another consideration in the choice of the FE or RE approach is the context of the data. The FE model is deemed appropriate when the units in a sample are exhaustive of the population, since the results are conditional on the particular units observed. In contrast, the RE model applies when the sample is a random sample of a large population about which inferences are to be made.

In the present study, the "population" is developing countries of which the sample of 63 countries makes up the majority. The sample seems to be fairly representative of the developing countries as a whole, and the analysis based on an FE formulation can reasonably be used to make inferences to the population even though the sample was not selected randomly. The FE approach is thus taken. Nevertheless, in the analysis that follows, a Hausman test is conducted for the correlation between the country-specific error

[20] The discussion of fixed versus random effects is based on a review of Deaton (1997, 105–108); Kennedy (1992, 222–223); Green (1997, 623–634); Baltaji (1995, Chapter 2); Balestra (1996, 30–31); Hsiao (1996, 93–95); and Ravallion and Chen (1997).

terms and the regressors (a test that is often used to inform the choice between the FE and RE models), and the RE results are presented for comparison.

The country FE model is as follows:

$$CM_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,it} + \mu_\iota + v_{it},\ v_{it} \sim N(0, \sigma^2), \tag{9}$$

where the μ_i is the unobservable country-specific, time-invariant effects and v_{it} is stochastic. The actual estimating equation is obtained by transforming the observations on each variable into deviations from the country-specific averages:

$$CM_{it} - \overline{CM}_i = \sum_{k=1}^{K} \beta_k (X_{k,it} - \overline{X}_{k,i}) + (\mu_i - \overline{\mu}_i) + (v_{it} - \overline{v}_i). \tag{10}$$

Since the μ_i are time-invariant, $(\mu_i - \overline{\mu}_i) = 0$, and the terms drop out of the model. Unbiased and consistent estimates of the β_k can be obtained using OLS estimation if the error term does not contain components that are correlated with an explanatory variable.[21]

In recognition of the differences in levels of causality implied in the conceptual framework, separate "reduced-form" equations are estimated for the underlying-determinant variables (health environment, women's education and status, and national food availability) and the basic-determinant variables (national income and democracy) for both pooled OLS and FE estimations. The ways in which the basic determinants work *through* the underlying determinants to affect child malnutrition can then be explored.

In each of the estimating equations, if the explanatory variables are correlated with the error term for any of the reasons outlined in Chapter 3, then biased estimates will result. The estimation strategy already addresses this problem as far as possible by (1) specifying estimating equations in which the hypothesized basic determinants are separated from the underlying determinants and (2) controlling for country-specific, time-invariant unobserved factors. The problem is further addressed by undertaking two sets of tests.

The first is the Ramsey Regression Specification Error Test (RESET) for omitted variable bias. To perform this test, a matrix *Z* is constructed of the second, third, and fourth moments of the fitted values of countries' child malnutrition prevalences. The equations are then re-estimated including the variables in *Z* as regressors. If the coeffi-

[21] From a practical standpoint, equation (9) can be estimated by including a dummy variable for each country, essentially allowing each country its own intercept term (thus the model is also known as the Least Squares Dummy Variable [LSDV] model). The first-differences approach is not used because there are many countries for which the sample contains more than two observations (see Table 2), in which case first differencing across individual countries' observations is no longer equivalent to fixed-effects estimation.

cients on the Z variables are jointly significant, the null hypothesis of no omitted variables bias is rejected (Haddad et al. 1995).

The second test is the Hausman-Wu instrumental variables (IV) test for endogeneity of the explanatory variables (Haddad et al. 1995; Davidson and Mackinnon 1993). In the presence of such endogeneity, the FE estimates are inconsistent (asymptotically biased). The Hausman-Wu test determines whether there is a significant difference between the FE parameter estimates and parameters estimated using IV estimation, of which the latter are consistent in the presence of endogeneity. The test is undertaken in two steps. First, the potentially endogenous variables are regressed on the remaining (assumed exogenous) variables and a set of "instruments." Such instruments must satisfy two conditions: (1) they must be good predictors of the potentially endogenous variables; and (2) they must not be associated with child malnutrition except through those variables.

To test for endogeneity of X_1 in the static FE model (equation 9), for example, given instruments $z_{11}, \ldots, z_{1G}$, the estimating equation is

$$X_{i,1t} = \gamma_0 + \sum_{k=2}^{K} \gamma_{k,it} + \mu_i + \sum_{g=1}^{G} \gamma_g Z_{1g} + \psi_{it}. \tag{11}$$

In the second step of the test, the dependent variable is regressed on all explanatory variables plus the predicted residuals from the first stage, denoted $\hat{\psi}_{it}$:

$$CM_{it} = \xi_0 + \sum_{k=1}^{K} \xi_k X_{k,it} + \mu_i + \eta\hat{\psi}_{it} + \Pi_{it}. \tag{12}$$

The null hypothesis that the explanatory variable is not endogenous is rejected if the coefficient on the predicted residuals is statistically significant. In the presence of endogeneity, IV estimates are consistent but not efficient. If there is no difference between the IV and (OLS-estimated) FE estimates, then the more efficient FE estimates are preferred. If, however, the IV estimates are significantly different from the FE estimates, then the IV estimates are preferred.

The credibility of the Hausman-Wu test results rests on the ability to locate proper instruments for the potentially endogenous variables. Before performing the tests, therefore, two further tests are conducted to find out if candidate instruments are appropriate. The first, a "relevance test," determines whether the selected instruments can in fact explain variation in the potentially endogenous variables to be instrumented (Bound, Jaeger, and Baker 1995). The test is an F test on the joint significance of the instruments in a predicting equation for each potentially endogenous variable. For the example, it is an F test of the joint significance of $z_{11}, \ldots, z_{1G}$, in equation (11). If the instruments are jointly significant, the null is rejected, and the instruments are considered "relevant." Note that the bias in IV estimates can be approximated by $1/F$ (where "F" is the F-test statistic), multiplied by the bias from FE estimation. Hence if $F = 1$ the IV estimates are as biased as the FE estimates.

The second test, an "overidentification test," determines whether the candidate instruments directly affect the dependent variable other than through the potentially endogenous variable to be instrumented (Davidson and Mackinnon 1993). It tests whether the instruments are correlated with the error term from IV estimation. Returning to the FE model example, the test takes place in two steps. In the first, the predicted residuals from a two-stage least squares regression of the child malnutrition equation denoted are calculated. In the second step, the predicted residuals are regressed on the exogenous variables and the instruments:

$$\hat{\Pi}_{it} = \theta_0 + \sum_{k=2}^{K} \theta_k X_{k,it} + \mu_i + \sum_{g=1}^{G} \theta_g Z_{1g} + E_{it} . \tag{13}$$

The statistic $N \times R^2$, where N is the number of observations, is distributed χ^2 with degrees of freedom equal to the number of instruments minus the number of potentially endogenous variables being tested (in the example, 1). The (joint) null hypothesis tested is that the instruments are uncorrelated with the error term from the child malnutrition equation and the model is correctly specified. This test can only be performed when there is more than one instrument.

If any set of instrumental variables does not pass the relevance test, then it is not employed for the Hausman-Wu test. If a sufficient number of instruments is available for performing the overidentification test and the test is not passed, then the instruments are not employed. The variables giving particular concern about endogeneity are food availability, national income, democracy, and safe water access, for which the possibility of reverse causality with child malnutrition exists.[22] For the latter variable, endogeneity due to measurement error is also a concern.

Chow *F*-tests for structural change are performed to determine whether there are significant differences across the developing-country regions in the parameter estimates. The sum of squared residuals (SSR) of a regression including all regions is compared with the sum of the SSR of five separate regressions, one for each region. An *F*-test is used to determine whether the null hypothesis that the parameter estimates are the same across the regions is rejected. Five separate tests are also conducted in which each region is successively removed from the full sample as a comparison group. This latter set of tests helps to identify which particular regions are the source of any differences.

Given the limitations of the unbalanced panel, it is not appropriate to estimate a two-way error components model in which period dummies are included in the regression equation (9). Nor is it possible to include a time trend as a regressor. This is because any particular year or even group of years (a decade, for example) is not

[22] Reverse causality for safe water access is a concern because governments may target safe water programs to areas with high malnutrition. Reverse causality for food availability and national incomes is a concern because malnourished people are likely to be less productive food producers and income earners. For democracy the concern is that malnourishment may lead to political instability, an environment not conducive to democratic governance.

available for all countries in the study. In this case, estimated period effects would not represent the effect of the time period for all countries. Their inclusion would misrepresent the period effects for the sample and population and inappropriately distort the regression coefficients on the substantive explanatory variables.

However, some of the dynamics of child malnutrition determination can be explored using a reduced sample. Next, three modifications of the base models that include lagged child malnutrition as a regressor and, where appropriate, a time trend are explored.[23] The first is a simple OLS model. Equation (8) is modified as follows:

$$CM_{it} = \beta_0 CM_{i,t-1} + \sum_{k=1}^{K} \beta_k X_{k,it} + u_{it},\ u_{it} \sim N(0, \sigma^2), \tag{14}$$

where $CM_{i,t-1}$ is the lagged value of CM_{it}.

The second dynamic specification is based on a fixed-effects approach. The base estimating equation is as follows:

$$CM_{it} = \beta_0 CM_{i,t-1} + \sum_{k=1}^{K} \beta_k X_{k,it} + \mu_i + v_{it},\ v_{it} \sim N(0, \sigma^2), \tag{15}$$

where v_{it} is stochastic. Equation (15) cannot be estimated using the standard OLS procedure. If $\beta_0 \neq 0$, $CM_{i,t}$ is a function of the error term, and OLS estimation yields biased and inconsistent estimates. Eliminating this bias requires, first, undertaking a first-difference transformation to wipe out the country fixed-effect term, yielding the following estimating equation:

$$\begin{aligned}(CM_{it} - CM_{i,t-1}) &= \beta_0 (CM_{i,t-1} - CM_{i,t-2}) \\ &\quad + \sum_{k=1}^{K} \beta_k (X_{k,it} - X_{k,i,t-1}) + (v_{it} - v_{i,t-1}).\end{aligned} \tag{16}$$

Second, the term $(CM_{i,t-1} - CM_{i,t-2})$ must be instrumented. The instrumental variable for the term is $(CM_{i,t-2})$ itself, which is correlated with $(CM_{i,t-1} - CM_{i,t-2})$ but not with $(v_{i,t} - v_{i,t-1})$ (Baltaji 1995).

The third dynamic specification adds to the second a time trend and initial values of the explanatory variables. The base estimating equation is

[23] The models presented here are termed "dynamic models," defined as those including lagged values of the dependent variable as regressors. The intention is to rely on the past behavior of the variable to be better able to model its current state. This is purely a distinction of statistical nomenclature and does not mean that results based on a statistically "static" specification cannot be used for making inferences about changes in a dependent variable over time.

$$CM_{it} = \beta_0 CM_{i,t-1} + \sum_{k=1}^{K} \beta_k X_{k,it} + \gamma t + \sum_{k=1}^{K} \theta_k t w_{k,i} + \mu_i + v_{it},\ v_{it} \sim N(0, \sigma^2), \quad (17)$$

where w_i is the initial value of an explanatory variable. These terms are interacted with the time trend in order to permit the effect of initial conditions on current child malnutrition to vary over time. A first-difference transformation yields the following estimating equation:

$$(CM_{it} - CM_{i,t-1}) = \beta_0 (CM_{i,t-1} - CM_{i,t-2})$$
$$+ \sum_{k=1}^{K} \beta_k (X_{k,it} - X_{k,i,t-1}) + \gamma S + \sum_{k=1}^{K} \theta_k w_{k,i} + (v_{it} - v_{i,t-1}), \quad (18)$$

where $S = t - (t-1)$, the length of the spell between the time periods. This term allows for uneven spacing of the observations across countries characterizing the unbalanced panel.[24] As for equation (16), the term $(CM_{i,t-1} - CM_{i,t-2})$ must be instrumented with $CM_{i,t-2}$. Because estimation of equations (16) and (18) requires three observations for each country, the estimations are undertaken with data from only 36 of the sample countries.

Before moving on to the estimation results, note that the data used in the regression analysis are not population-weighted. This is because the countries, not people, are the unit of analysis, and the goal is to use the variation across countries to draw out the relationships between child malnutrition and determinants measured at the national level. However, the effects of population size have been controlled for in the construction of the explanatory variables where needed, and the fixed-effects analysis partially controls for large differences in population across countries.

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[24] The usual constant (which is replaced by the term γS) is suppressed.

CHAPTER 5

Estimation Results: New Evidence from Cross-Country Data, 1970–96

Descriptive Analysis

Child malnutrition prevalences and means of the explanatory variables are presented in Table 4 by developing region and decade.[25] The numbers for the developing countries as a whole are given in Table 5. Figures 2–7 show the country-level data: child malnutrition prevalences are plotted against each variable using data pooled across all countries and time periods. The fitted lines in each figure are arrived at using a Lowess smoothing technique.[26]

The regional trends and levels of child malnutrition in the sample closely follow those for the developing countries as a whole in Table 1. South Asia had the highest prevalence of child malnutrition during the period, with a rate roughly double that of the next highest region, Sub-Saharan Africa (Table 4). More than half of all South Asian children under five were underweight for their age. Roughly one-third were underweight in Sub-Saharan Africa and one-fifth in East Asia. NENA and LAC had the lowest underweight rates. The regions whose rates have declined the most are South Asia and East Asia. Sub-Saharan Africa is the only region for which underweight rates have increased.

Turning to the underlying-determinant explanatory variables, NENA and LAC had the highest overall rates of access to safe water, more than 70 percent, while Sub-Saharan Africa had the lowest at 37.5 percent, illustrating the high degree of inequality across the regions (Table 4, column 2). Improvements in access to safe water during the study period have been extraordinary. For the full sample, the percentage of people

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[25] The measures of the explanatory variables are used in the tables and figures throughout this report. For example, “female-to-male life expectancy ratio” is given instead of “women’s status relative to men’s.”

[26] The Lowess smoother produces locally weighted regression smoothing, using iterative weighted least squares (SPSS 1993).

Table 4—Regional comparison of sample child malnutrition (underweight) prevalences and explanatory variable means, 1970s, 1980s, and 1990s

Region/decade	Child malnutrition (1)	Access to safe water (2)	Female secondary school enrollment (3)	Female-to-male life expectancy ratio (4)	Per capita dietary energy supply (5)	Per capita GDP (6)	Democracy (7)
	(percent)	(percent)	(percent)		(kilocalories)	($PPP)	(1=least democratic)
South Asia	61.0	60.5	23.8	1.010	2,187	863	4.59
1970s (n=4)	69.1	29.8	16.3	0.987	2,023	728	4.38
1980s (n=6)	61.8	51.9	14.2	1.020	2,042	719	3.25
1990s (n=6)	55.7	81.3	31.5	1.022	2,332	990	5.16
Sub-Saharan Africa	31.0	37.5	15.6	1.061	2,164	879	2.57
1970s (n=10)	27.2	24.7	8.5	1.069	2,207	1,358	1.77
1980s (n=26)	26.5	35.0	14.6	1.066	2,117	1,031	2.02
1990s (n=29)	33.7	40.4	17.0	1.060	2,184	740	2.96
East Asia	23.0	64.5	47.9	1.051	2,595	1,874	1.69
1970s (n=2)	45.0	19.7	25.8	1.050	2,007	1,402	3.0
1980s (n=13)	26.8	63.8	39.2	1.053	2,502	1,483	2.30
1990s (n=11)	19.4	67.8	54.4	1.049	2,686	2,132	1.25
Near East and North Africa	11.0	75.5	52.5	1.043	3,058	2,527	2.81
1970s (n=3)	16.5	72.5	34.0	1.042	2,710	1,547	3.32
1980s (n=4)	10.1	69.3	46.4	1.043	3,018	2,746	3.09
1990s (n=7)	10.8	79.4	59.7	1.043	3,157	2,637	2.55
Latin America and the Caribbean	12.0	71.8	44.8	1.094	2,647	4,740	4.73
1970s (n=12)	18.9	59.5	33.3	1.086	2,620	4,713	4.06
1980s (n=26)	11.4	79.0	47.2	1.096	2,675	4,871	5.14
1990s (n=20)	8.3	73.3	51.4	1.098	2,636	4,607	4.79

Notes: The means reported in this table are calculated based only on the country-year pairs included in the study data set. They are population-weighted.

Table 5—Child malnutrition (underweight) prevalences and explanatory variable means, 1970s, 1980s, and 1990s

Variable	1970s	1980s	1990s	Change 1970s to 1990s	Percent change 1970s to 1990s
Child malnutrition (percent)	50.7	29.0	28.5	–22.2	–43.8
Access to safe water (percent)	36.3	61.6	69.0	32.7	+90
Female secondary school enrollment (percent)	21.7	34.5	45.0	23.3	+107
Female-to-male life expectancy ratio	1.024	1.055	1.047	0.023	+2.25
Per capita dietary energy supply (kilocalories)	2,187	2,440	2,564	377	+17.2
Per capita GDP ($)	1,772	1,871	1,904	132	+7.45
Democracy (1 = least democratic)	3.96	2.86	2.66	–1.3	–32.8
Number of observations	31	75	73	. . .	. . .
Number of countries	29	54	58	. . .	. . .

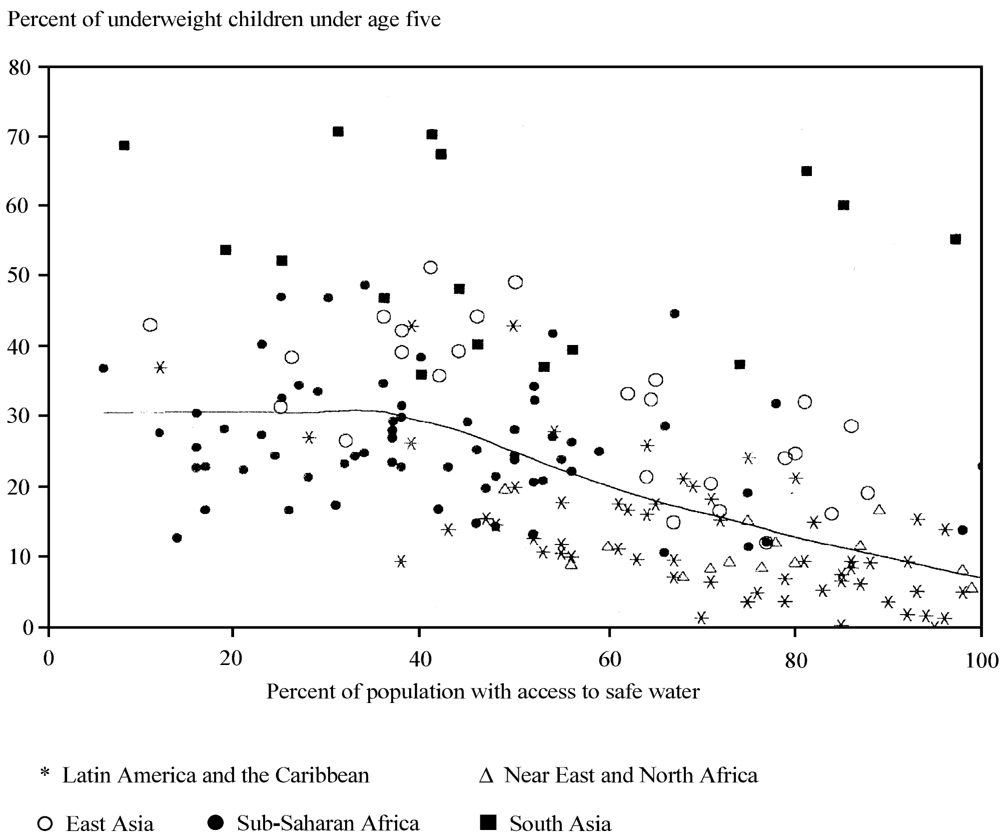
Note: The means reported in this table are calculated based only on the country-year pairs included in the study data set, and therefore must be considered illustrative (see Table 10 for an alternative estimation of the changes in time using data on all of the study countries for consecutive five-year intervals). They are population-weighted.

having access to safe water more than doubled, starting at 36.3 percent in the 1970s, increasing quickly to 61.6 percent in the 1980s, and rising to 69 percent by the 1990s (Table 5). The rates of improvement were greatest for East Asia and South Asia. Figure 2 illustrates that the negative association between national rates of access to safe water and child malnutrition is fairly strong, especially after a safe water access rate of 40 percent has been reached.

With respect to women's education, Sub-Saharan Africa had the lowest rate of enrollment in secondary school, at 15.6 percent (Table 4, column 3). South Asia's rate, at only 23.8 percent, was also very low. For the full sample, female secondary school enrollment rates improved steadily during the period, rising from 21.7 percent in the 1970s to 45 percent in the 1990s. Nevertheless they remain quite low, with less than half of the age-eligible women in developing countries entering secondary school. Figure 3 shows the negative association between female secondary school enrollments and child malnutrition rates. The association is especially strong where female enrollment rates are very low (below 40 percent).

The indicator of women's status relative to men's was the lowest by far in South Asia, with female and male life expectancy being roughly equal (Table 4, column 4). Women's life expectancy in the developed countries is on average six to seven years longer than men's (Mohiuddin 1996). The ratio in Norway, for example, is 1.08. Thus South Asia's ratio of 1.01 is extremely low. Sub-Saharan Africa, East Asia, and NENA have ratios of 1.06, 1.05, and 1.04, respectively, still below what is common in developed countries. LAC had the highest ratio of the developing-country regions, which at 1.09 is on a par with the developed-country level. Over time, the

Figure 2—Prevalence of underweight children by access to safe water, by region, 1970–96

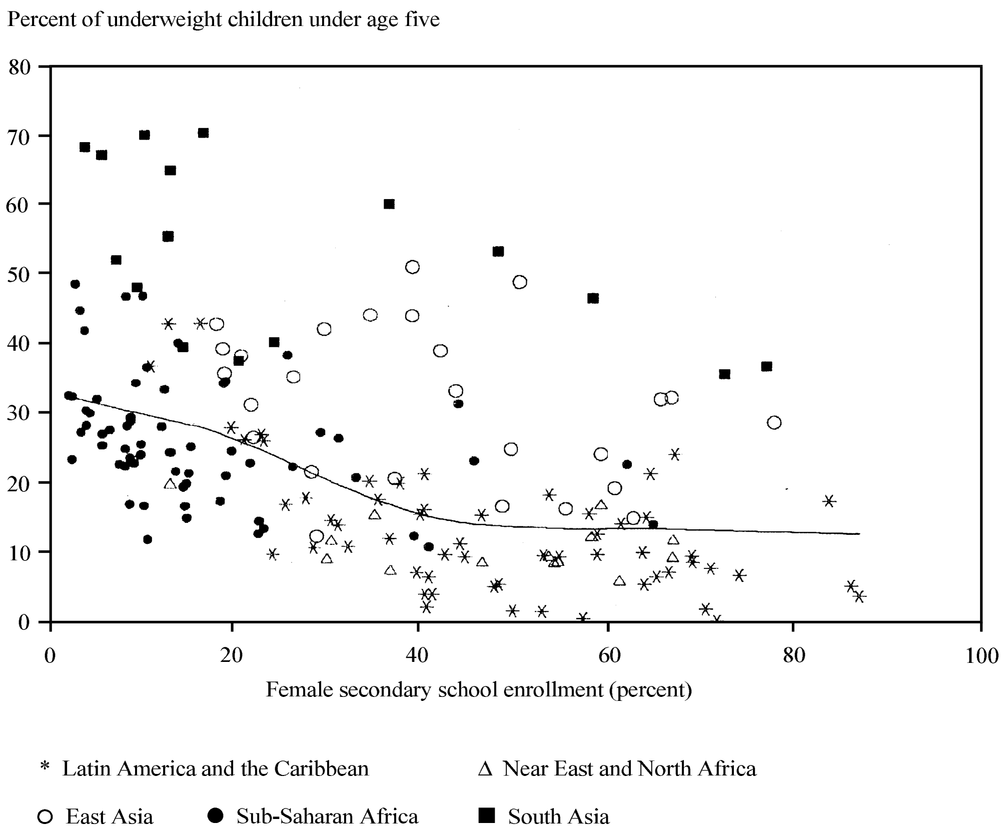


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

ratio for the developing countries as a group increased from 1.02 in the 1970s to 1.05 in the 1990s (Table 5). This change, while small in absolute terms, is equal to about one-eighth of the variable's entire range (0.97 to 1.12—see below). The ratio has improved or remained fairly steady in all regions except Sub-Saharan Africa. The negative association between life expectancy ratios and child malnutrition prevalences is fairly strong for the sample as a whole (Figure 4). The relationship appears to be very strong at lower life expectancy ratios, where most of the South Asian data points fall, flattening out after about 1.05.

Per capita DESs were lowest in South Asia and Sub-Saharan Africa during the period. The minimum daily dietary energy requirement for an active and healthy life is about 2,150 kilocalories (FAO 1996). *Supplies* (not intake) in these regions barely surpassed this requirement (Table 4, column 5). The minimum DES considered necessary (but not sufficient) for bringing the share of food insecure to a very low 2.5 percent of a

Figure 3—Prevalence of underweight children by female secondary school enrollment, by region, 1970–96

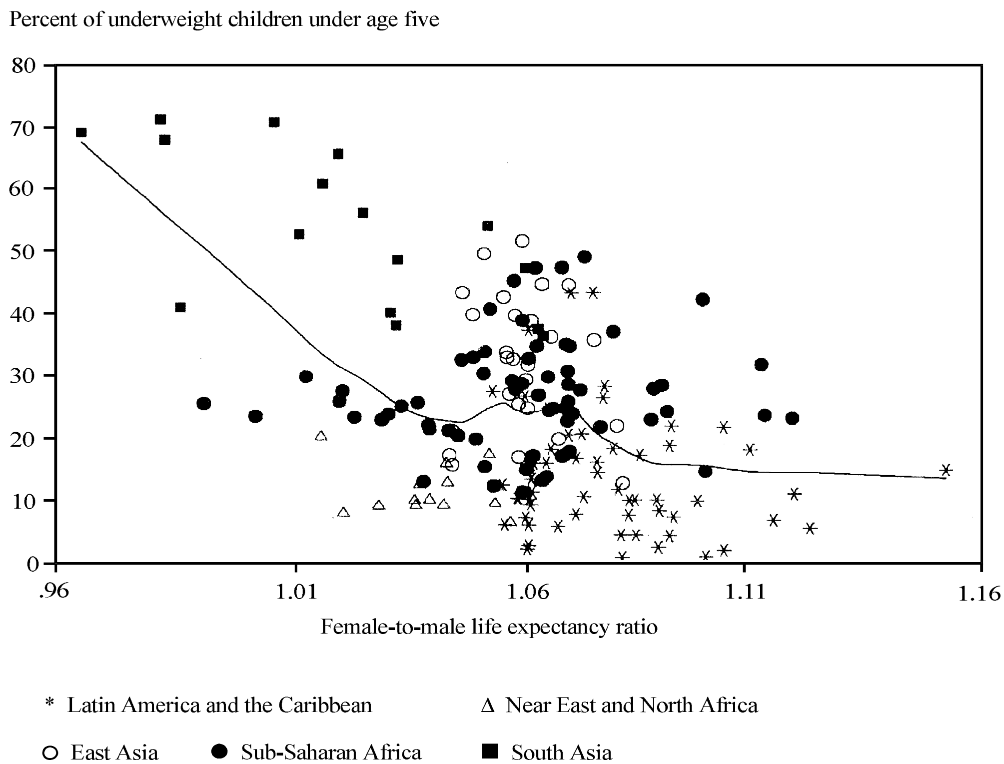


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

country's population is 2,770 kilocalories (FAO 1996). The dietary energy supplies of East Asia and LAC neared this level; NENA's surpassed it. From the 1970s to the 1990s, DES increased in all regions except Sub-Saharan Africa. Figure 5 points to a strong negative association between DES and child malnutrition rates.

Per capita GDP was lowest for South Asia and Sub-Saharan Africa and highest for LAC (Table 4, column 6). From a descriptive standpoint, Figure 6 indicates a negative relationship between per capita national incomes and child malnutrition in developing countries. However, at the extremes there is much less correspondence. Two observations are worth noting. First, above a per capita GDP threshold of $3,000, it is rare to find a child underweight rate above 25 percent. Most of the LAC and NENA data points fall into this category. Second, below a per capita GDP of $2,000, where most of the Sub-Saharan African and South Asian data points lie, there are striking differences in the prevalences, ranging from 12 percent to

Figure 4—Prevalence of underweight children by female-to-male life expectancy ratio, by region, 1970–96

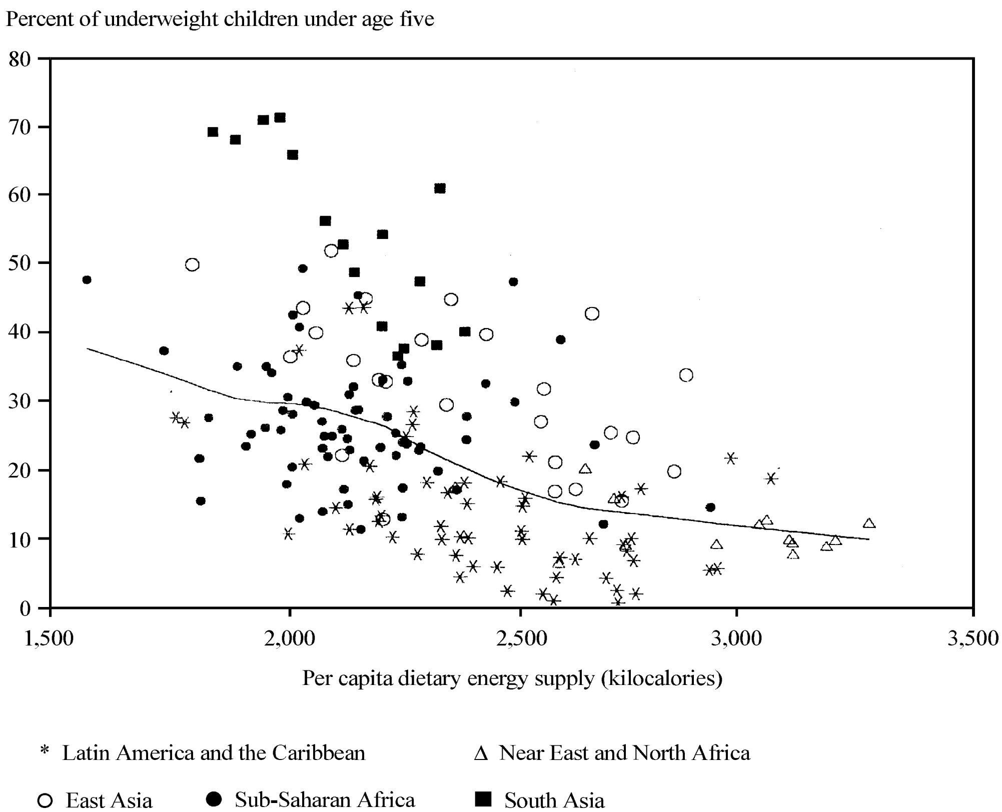


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

71 percent. While high income and high child malnutrition generally do not coexist, it is possible—and not uncommon—for countries to achieve low levels of child malnutrition even with low per capita incomes. Some countries in the sample for which this is the case are Côte d'Ivoire (in 1986), Lesotho (in 1981), Nicaragua (in 1993), and Zimbabwe (in 1994).

The region that has been least democratic during the study period is East Asia (Table 4, column 7). Interestingly, South Asia and LAC, while at opposite extremes on underweight rates, appear to have been equally democratic over the 25-year period. These regions had the highest democracy index scores. Democracy has improved for South Asia, Sub-Saharan Africa, and LAC; it has deteriorated for East Asia and NENA. It is the only explanatory variable that has declined for the developing-country sample as a whole, falling from about 4.0 in the 1970s to 2.7 in the 1990s (Table 5). Figure 7 illustrates that the regions vary widely around the regional means reported in Table 4, and that the association between democracy and underweight is distinctly negative, especially at the democracy index extremes.

Figure 5—Prevalence of underweight children by per capita dietary energy supply, by region, 1970–96

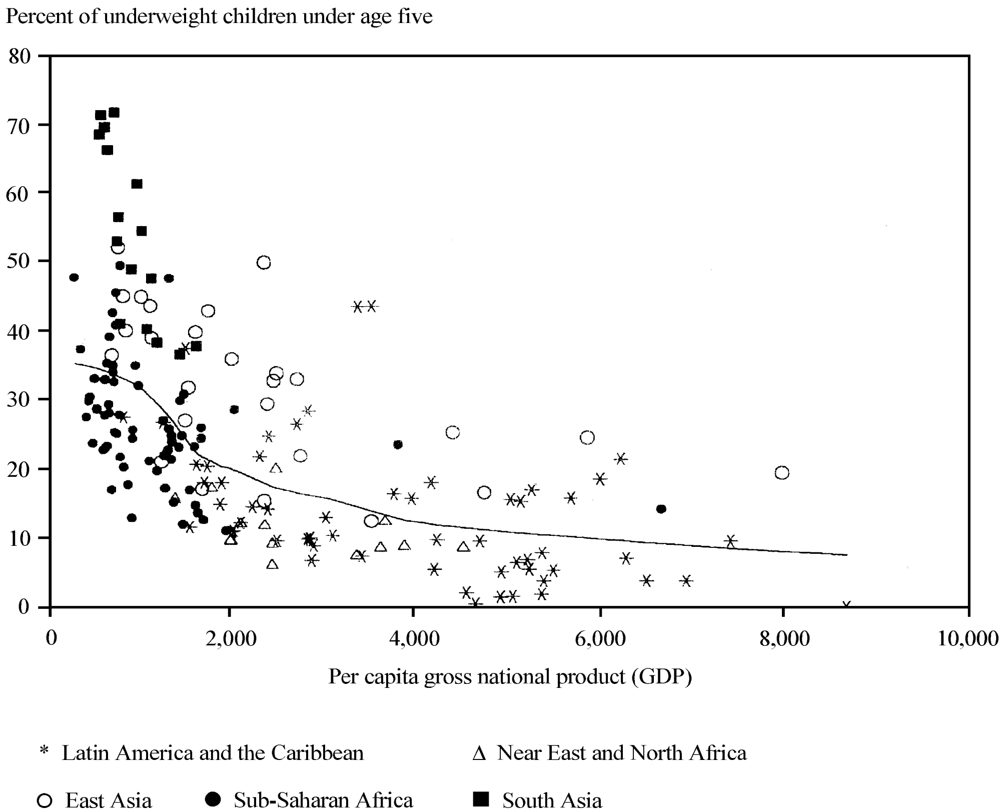


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Multivariate Analysis

According to the descriptive analysis of the last section, improvements in all of the hypothesized explanatory variables lead to reductions in child malnutrition. However, the bi-variate relationships identified may mask the variables' confounding influences. The goal of this section is to single out the independent effect of each variable, while controlling for the others. In the section, the parameter estimates for the static models and the results of the specification tests are first presented. Next, the practical significance of the parameter estimates are discussed, and the possibility of significant regional differences is investigated. Finally, the determinants of child malnutrition are explored from a dynamic perspective.

Figure 6—Prevalence of underweight children by per capita GDP, by region, 1970–96

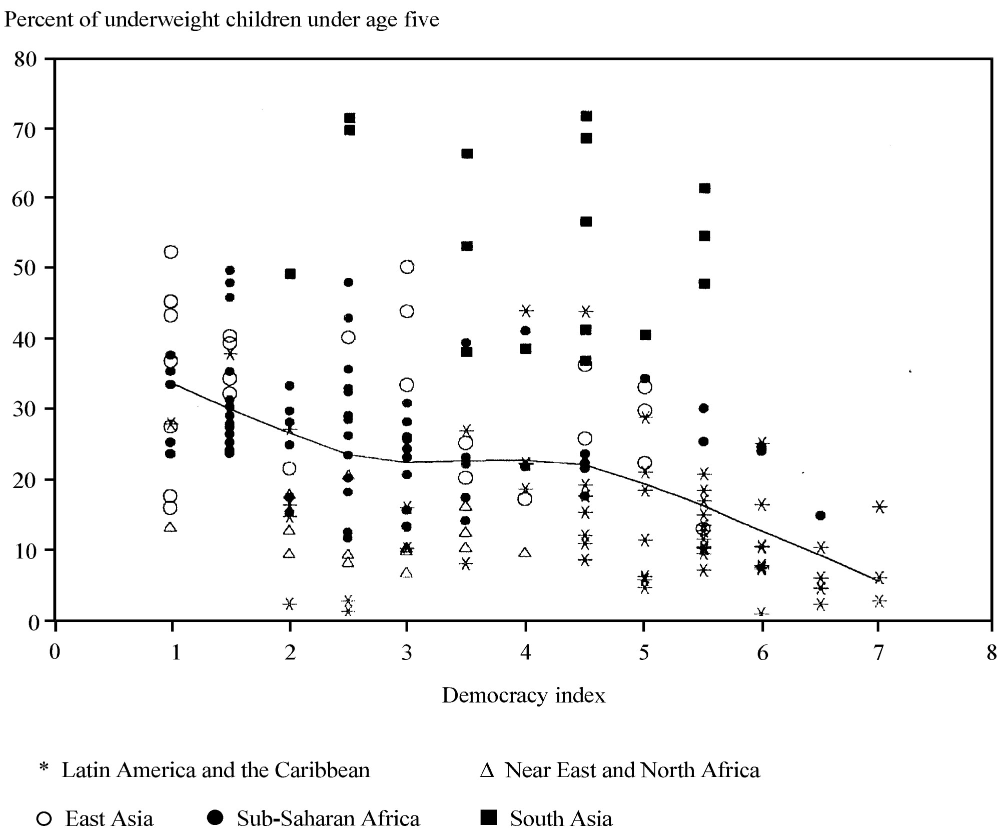


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Estimation Results for Static Models

Parameter Estimates. The pooled OLS and country FE estimation results are presented in Table 6. Here all independent variables are assumed to enter into equations (8) and (9) linearly. Tests for nonlinearities in the FE estimating equations reveal a curvilinear relationship between child malnutrition prevalence and two variables: per capita *DES* and per capita *GDP*. The estimation results when these relationships are taken into account are given in Table 7. The final preferred estimates are those generated using FE estimation and three-segment linear splines to represent the *CM-DES* and *CM-GDP* relationships. Nevertheless, the other estimations are presented and discussed in order to demonstrate a number of methodological points.

Figure 7—Prevalence of underweight children by democracy index, by region, 1970–96



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Table 6 compares the pooled OLS and FE estimation results for both the underlying-determinants model and the basic-determinants model. The only difference between the OLS and FE estimating equations is the inclusion of 63 country-specific dummy variables in the latter. *F*-tests for the joint significance of the dummy variables strongly reject the null hypothesis that they have no impact on child malnutrition.

A comparison of the pooled OLS and linear FE parameter estimates points to some important differences. First, for the underlying-determinant specifications, once the country fixed-effects terms are included, the magnitudes of the coefficients on safe water access (*SAFEW*), the female-to-male life expectancy ratio (*LFEXPRAT*), and *DES* drop substantially, and they lose statistical significance. This finding indicates that OLS estimates of the effects of these variables on child malnutrition are biased upward. Second, while the OLS estimates suggest that the effect of female secondary

Table 6—Child malnutrition regressions: Ordinary least squares and country fixed effects, linear specifications

Variable	Pooled ordinary least squares (OLS)		Country fixed effects (FE)		
	Underlying determinants (1)	Basic determinants (2)	Underlying determinants (3)	Basic determinants (4)	All determinants (5)
Access to safe water (*SAFEW*)	–.139 (2.7)***	. . .	–.085 (2.14)**	. . .	–.069 (1.7)*
Female secondary school enrollment (*FEMSED*)	–.068 (1.27)	. . .	–.167 (2.64)***	. . .	–.177 (2.78)***
Female-to-male life expectancy ratio (*LFEXPRAT*)	–177 (5.23)***	. . .	–93.45 (2.25)**	. . .	–111 (2.6)**
Per capita dietary energy supply (*DES*)	– .012 (3.65)***	. . .	–.0081 (2.48)**	. . .	–.0077 (2.21)**
Per capita GDP (*GDP*)	. . .	–.0048 (8.2)***	. . .	–.0023 (2.46)**	1.20E-04 (.137)
Democracy (*DEMOC*)	. . .	–.274 (.44)	. . .	–.884 (1.67)*	–.779 (1.68)*
R^2	.433	.346	.943	.916	.945
Adjusted R^2	.420	.338	.910	.869	.910

Notes: The dependent variable is prevalence of underweight children under five. The number of observations for all regressions is 179 (63 countries). Absolute values of *t*-statistics are given in parentheses.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

school enrollment (*FEMSED*) is statistically insignificant and small, the FE results indicate strong statistical significance and a much stronger effect (the coefficient on *FEMSED* is 150 percent higher). OLS estimates of the effects of female education are thus biased downward. For the basic determinant specifications, the OLS coefficient estimate for *GDP* is biased upward; that for democracy (*DEMOC*) is biased downward. These differences illustrate the strong biases that result when unobserved country-specific, time-invariant factors are omitted from regression analysis of the determinants of child malnutrition.

Column (5) of Table 6 contains FE estimation results when both underlying and basic determinants are combined in the same estimating equation. While the parameter estimates of the four underlying determinants and *DEMOC* differ little from the FE separate-model estimates, the magnitude of the coefficient estimate for *GDP* declines substantially and becomes statistically insignificant. The combined-model specification suggests a weak relationship between per capita national income and child malnutrition.

Table 7—Child malnutrition regressions: Country fixed effects, nonlinear specifications

Variable	Quadratic *DES* and *GDP* curves: Underlying determinants (1)	Quadratic *DES* and *GDP* curves: Basic determinants (2)	Three-segment linear spline *DES* and *GDP* curves: Underlying determinants (3)	Three-segment linear spline *DES* and *GDP* curves: Basic determinants (4)
Access to safe water (*SAFEW*)	–.072 (1.84)*	. . .	–.076 (1.95)*	. . .
Female secondary school enrollment (*FEMSED*)	–.232 (3.51)***	. . .	–.220 (3.41)***	. . .
Female-to-male life expectancy ratio (*LFEXPRAT*)	–74.89 (1.83)*	. . .	–71.8 (1.74)*	. . .
Per capita dietary energy supply (*DES*)	–.067 (3.00)***	. . .	. . .	. . .
DES^2	1.24E-05 (2.66)***	. . .	. . .	. . .
DES spline				
DES ≤ 2,300 (n = 93)	. . .	. . .	–.0170 (3.41)***	. . .
2,300 < *DES* ≤ 3,120 (n = 83)	. . .	. . .	–.0024 (2.16)**	. . .
DES > 3,120 (n = 3)[a]	. . .	. . .	.0405 (1.35)	. . .
Per capita GDP (*GDP*)	. . .	–.0121 (4.68)***	. . .	. . .
GDP^2	. . .	9.67E-07 (4.03)***	. . .	. . .
GDP spline				
GDP ≤ 800 (n = 37)	. . .	. . .	. . .	–.0444 (3.15)***
800 < *GDP* ≤ 4,725 (n = 118)	. . .	. . .	. . .	–.0067 (2.63)***
GDP > 4,725 (n = 24)	. . .	. . .	. . .	.0006 (3.37)***
Democracy (*DEMOC*)	. . .	–1.45 (2.81)***	. . .	–1.27 (2.51)**
R^2	.947	.927	.947	.930
Adjusted R^2	.914	.884	.914	.889

Notes: The dependent variable is prevalence of underweight children under five. The number of observations for all regressions is 179 (63 countries). Absolute values of *t*-statistics are given in parentheses.

[a] The choice of spline segments is the result of a grid search with minimum sum of squared residuals as the criterion. The coefficient on the third segment remains positive and statistically insignificant even when the cut-off point is lowered considerably (which would make the number of data points sufficient for the estimation of a significant coefficient).

* Significant at the 10 percent level.

** Significant at the 5 percent level.

*** Significant at the 1 percent level.

The separate-model specification, on the other hand, suggests a statistically significant and practically strong relationship. These contrasts illustrate the dangers of combining variables at very different levels of causality in the same regression when the intention is to estimate the independent effects of the variables.

Starting from the FE models, tests for the significance of all quadratic and interaction terms are undertaken to determine whether any nonlinear relationships exist between child malnutrition and its determinants.[27] No statistically significant interaction terms were detected.[28] However, coefficients on quadratic terms for both *DES* and *GDP* are statistically significant and positive, indicating that they work to reduce child malnutrition but have a declining marginal effect. Along with the quadratic, a number of alternative functional forms were fitted to determine which best captures the curvature.

For *DES,* the quadratic provides a better fit than both reciprocal and linear log specifications. The estimation results for the quadratic specification are given in column (1) of Table 7. The turning point in the *CM-DES* curve is 2,727 kilocalories per capita. The result suggests that, after the turning point, increased per capita *DES* works to *worsen* child malnutrition. The study sample contains 29 data points (mostly in the Latin America and Caribbean and Near East and North Africa regions) that fall above this number. While a declining marginal effect is intuitive, a positive one is not.

To test whether the quadratic upturn is in fact implied by the data rather than "forced" on it by the functional form, the curve was fitted as a linear spline. An extensive grid search was undertaken to locate the knot combinations yielding the smallest sum of squared residuals. The best fitting function was a three-segment spline with optimal knots at 2,300 and 3,120 kilocalories.[29] Next, with the lower knot anchored at 2,300, a spline function with the second knot at 2,727 kilocalories was estimated. The coefficient on the third segment of the spline was positive but insignificant ($t = 1.0$). Hence, the upturn implied by the quadratic function is not substantiated by the data, and the spline-generated estimates are preferred.

The linear spline estimates are reported in Table 7, column (3). The first and second segments of the spline have negative and significant slopes, with the second having a much smaller slope than the first. The coefficient of the third segment is not statistically different from zero. The quadratic and spline specifications differ little in terms of overall fit and in the coefficients on the non-*DES* explanatory variables. However, their shape differs substantially at high levels of *DES,* as illustrated in Figure 8.

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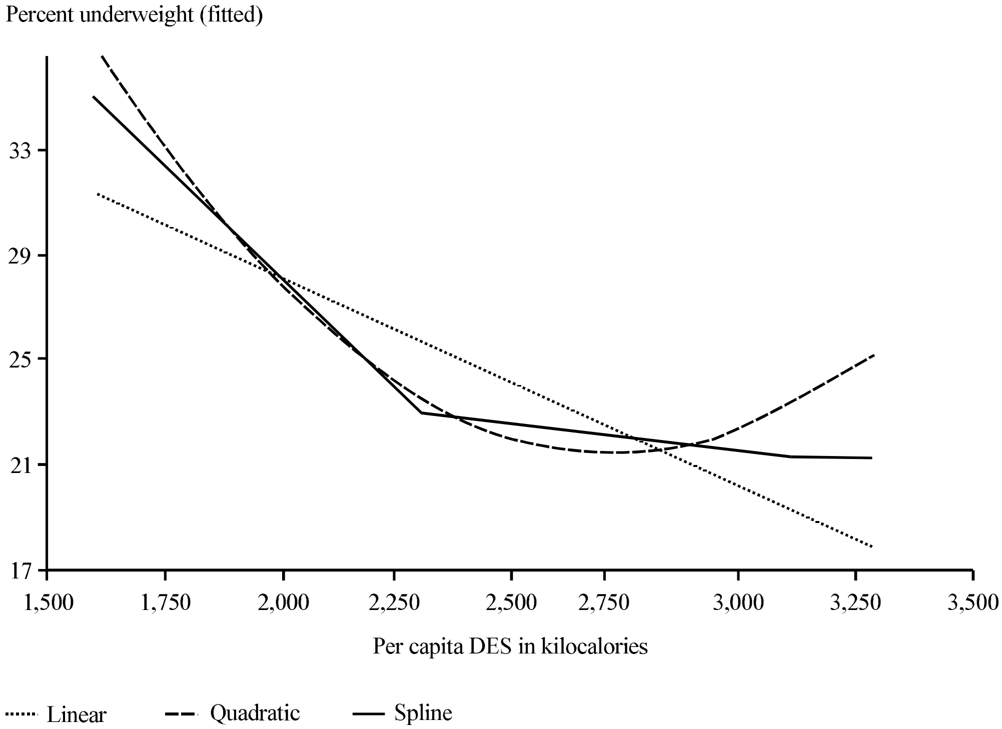
[27] Other available tests of nonlinearities are based on comparisons of subsamples of data across the range of an independent variable (Chow *F*-tests for structural change, Utts Rainbow test, the *CUSUM* test, see Green 1997; Haddad et al. 1995). Because subsamples of data in the set do not contain the same countries, the same fixed-effects terms do not apply to them all. Thus the tests are not valid for detecting nonlinearities in country fixed-effects analysis.

[28] Note, however, that micro-level studies have found evidence of significant interactions between the various determinants of child malnutrition, for example between food security and health (Haddad et al. 1996).

[29] Two knot sets proved to fit the data equally well: (2,300; 3,120) and (2,280; 2,940). For both, the coefficients on the third segment were statistically insignificant (n.b. the number of sample data points with *DES*. 3,120 is 3; the number with *DES* 2,940 is 13). The former was chosen because it allows more data from the sample to be used for estimations of the coefficients for the usable (first two) segments, thus producing more efficient parameter estimates for them.

Figure 8—Prevalence of underweight children and per capita dietary energy supply (DES): Linear, quadratic, and spline curves

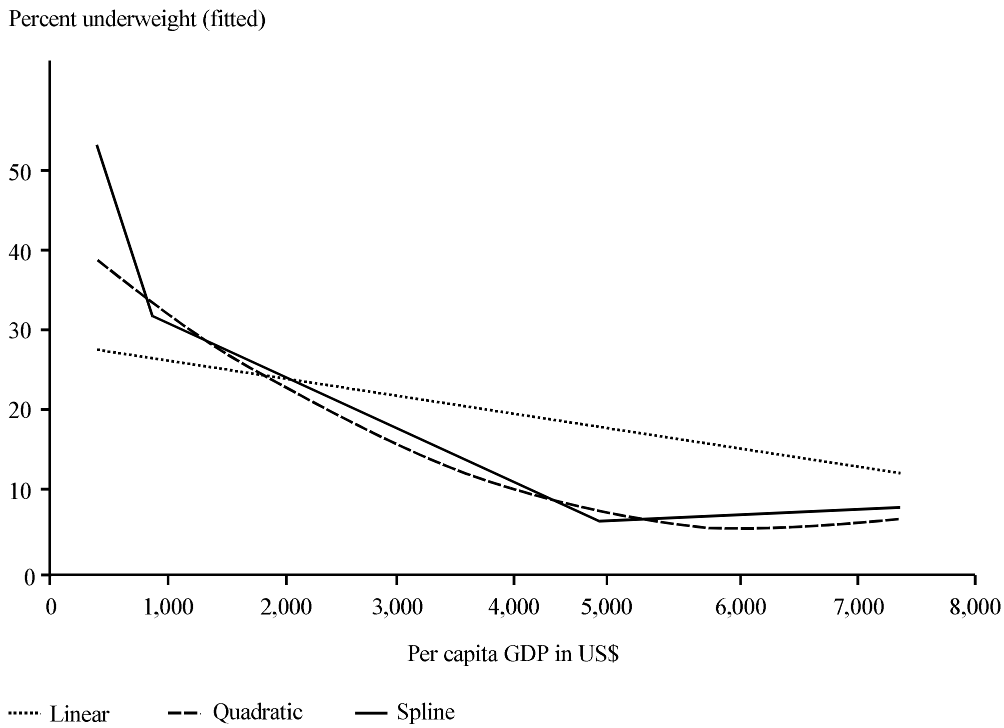


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

As for *DES*, the quadratic form of the *CM-GDP* relationship provides a better fit than other nonlinear specifications. The estimation results for the quadratic specification are given in column (2) of Table 7. The turning point in the function is $6,250. Linear spline fitting results in a three-segment spline with optimal knots at $800 and $4,750. The estimation results are presented in column (4) of Table 7. As for *DES,* the first and second segments of the spline have negative and significant slopes, with the second having a much flatter slope than the first. The last segment has a positive (though very small) and statistically significant slope, suggesting the possible existence of a slight upturn in the function after its second knot (Figure 9).

In addition to the estimated quadratic and spline curves, Figures 8 and 9 show the estimated *CM-DES* and *CM-GDP* functions when a linear form is assumed. For the underlying-determinants model, an *F*-test of the hypothesis that the actual slope of the function is constant is rejected at the 5 percent level; for the basic-determinants model, the hypothesis is rejected at 1 percent. These results confirm substantial nonlinearity in the *CM-DES* and *CM-GDP* relationships.

Figure 9—Prevalence of underweight children and per capita gross domestic product (GDP): Linear, quadratic, and spline curves



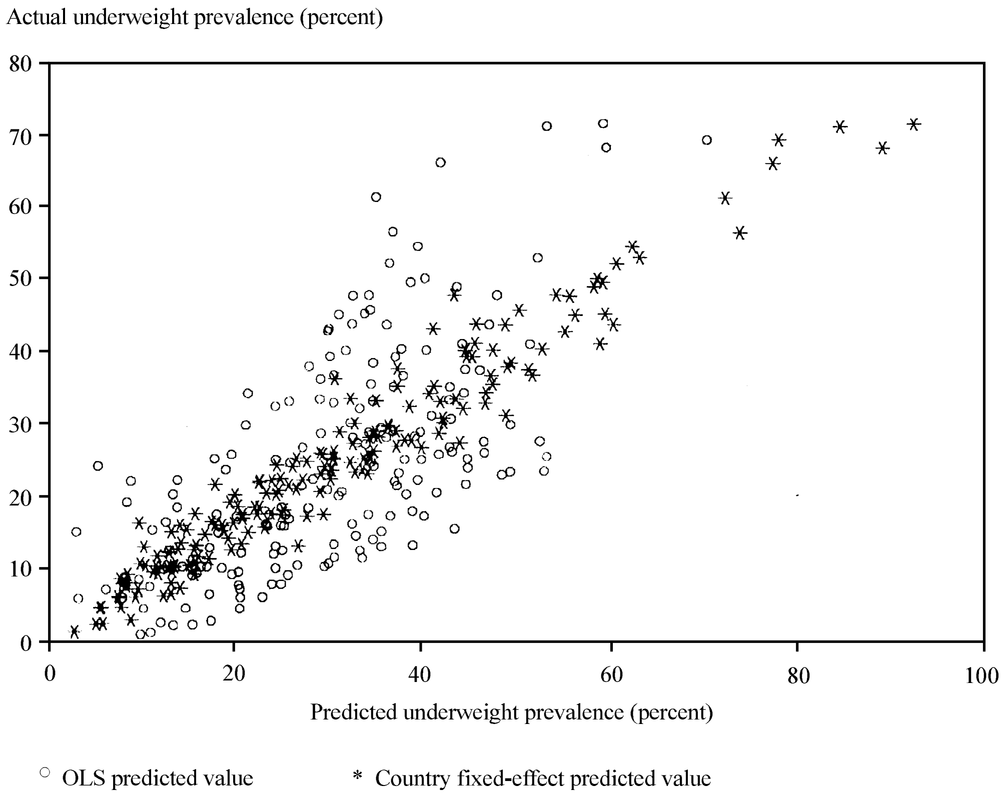
Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

The parameter estimates derived from the spline specifications in columns (3) and (4) of Table 7 are adopted as the preferred estimates for the policy analyses of Chapters 6, 7, and 8. However, the quadratic estimations are employed for the specification tests (see the next section) due to greatly reduced time costs.

In Figure 10, the predicted child malnutrition prevalences generated from pooled OLS and the preferred spline-generated FE estimations are plotted against the actual prevalences for the underlying-determinants model. Figure 11 shows the same comparison for the basic-determinants model. As both figures illustrate, the preferred estimates yield much more accurate in-sample predictions. Most of the difference is due to the inclusion of the fixed-effects terms (rather than the allowance of nonlinearities). It is interesting to note that the data points exhibiting the greatest error in the OLS estimates relative to the FE estimates are mainly from South Asia.[30] This suggests that the

[30] In Figure 8, the OLS data points exhibiting the greatest error are for Bangladesh (4), India (2), Sri Lanka (2), and Viet Nam (1). In Figure 9, the data points are Bangladesh (4), India (2), Sri Lanka (1), Nepal (1), Philippines (1), and Guatemala (2).

Figure 10—Actual underweight prevalences, by predicted prevalences for OLS and country fixed effects, underlying determinant models



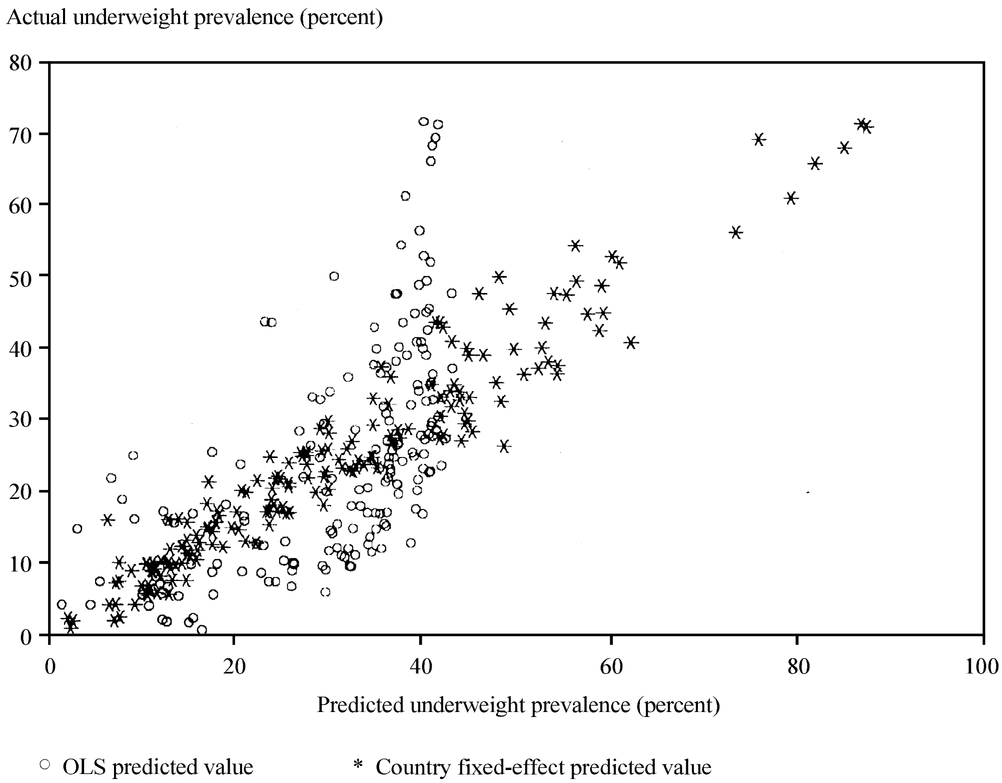
Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

importance of country-specific, time-invariant factors in influencing child malnutrition in South Asian countries is greater than that for the other regions, a finding that will be addressed in more detail later.

According to the conceptual framework (Figure 1) and comparison of the separate-model and combined-model specification presented earlier, the basic determinants affect child malnutrition *through* their influence on the underlying determinants. Table 8 gives country fixed-effects regression estimates of the impact of *GDP* and *DEMOC* on each underlying determinant using the quadratic form for the *CM-GDP* curve. All parameter estimates are statistically significant except for *DEMOC* in the *FEMSED* (column 2) and *LFEXPRAT* (column 3) equations.

Specification Tests. *Ramsey RESET test for Omitted Variables (OV) bias.* The FE basic-determinants model weakly rejects the null hypothesis that the Z matrix proxy variables are zero, that is, that no OV bias exists. The null hypothesis is rejected at the

Figure 11—Actual underweight prevalences, by predicted prevalences for OLS and country fixed effects, basic determinant models



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

5 percent level but not at the 1 percent level. For the underlying-determinant FE model the null hypothesis is not rejected. This indicates that the preferred FE specifications are probably not plagued by serious OV bias, but with more confidence in the underlying-determinant than basic-determinant specification. Note that the OLS basic-determinants model strongly rejects the null hypothesis, suggesting that there is strong OV bias in the parameter estimates. For the underlying-determinant model the null is weakly rejected (at a 5 percent significance level).

Hausman-Wu endogeneity tests. The instrumental variable candidates for the Hausman-Wu tests are listed in Table 9. Only one instrument each is identified for *SAFEW* and *LFEXPRAT.* Multiple instruments are available for *FEMSED, DES,* and *GDP.* The rationale for selection of each instrument is given in the table, along with the data sources. The instruments “arable land per capita” and “economic openness” are not significantly correlated with *DES* and *GDP,* respectively (see last column). They are thus excluded from further testing. No instrument is identified for *DEMOC.*

Table 8—Underlying-determinant variable regressions with basic-determinant variables as independent variables

Variable	Access to safe water (*SAFEW*) (1)	Female secondary school enrollment (*FEMSED*) (2)	Female-to-male life expectancy ratio (*LFEXPRAT*) (3)	Per capita dietary energy supply (*DES*) (4)
Per capita GDP (*GDP*)	.0174	.0148	1.0E-05	.4105
	(2.85)***	(3.71)***	(1.90)*	(6.26)***
GDP^2	–1.31E-06	–9.32E-07	–8.2E-10	–2.79E-05
	(2.31)**	(2.53)**	(1.67)*	(4.59)***
Democracy (*DEMOC*)	3.49	.981	–.002	26.28
	(2.87)***	(1.23)	(1.57)	(2.0)**
R^2	.835	.922	.901	.902
Adjusted R^2	.740	.877	.845	.846

Notes: The number of observations for all regressions is 179 (63 countries). Absolute values of *t*-statistics are given in parentheses. The regressions are estimated using a country fixed-effects spccification.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

Table 10 reports the results of the relevance, overidentification, and Hausman-Wu tests for the FE model specifications. The tests for *SAFEW* and *LFEXPRAT* are restricted to subsamples of the full sample because data on their instruments are scarce.

The instrument for *LFEXPRAT* (percent of births attended by health staff) does not pass the relevance test. Therefore, the Hausman-Wu test cannot be performed for the women's relative status indicator. One set of instruments for *DES*—land in cereal production, fertilizer use, and irrigated land—also does not pass the relevance test. Fortunately, another set, that containing only fertilizer use and irrigated land, passes the test at a 5 percent significance level. One set of instruments for *FEMSED*—male primary enrollments and public expenditures on education—also does not pass the relevance test. Two other sets do, however. The instrument for *SAFEW* (water resources) and the instrument set for *GDP* (investment share of GDP and foreign investment share of GDP), also pass the relevance test. For all relevant instrument sets, F >1. Thus IV estimates, if deemed preferable, would be less biased than the FE estimates.

The overidentification test cannot be performed for *SAFEW* as only one instrument is available. While there is no statistical evidence that this variable is not correlated with the error term in the *CHMAL* equation, intuition suggests that it is not (see "Rationale for Instrument Choice" in Table 9). Therefore, the Hausman-Wu test is performed, assuming that the water resource instrument is valid despite its limitations. For *FEMSED,* only the instrument set containing the availability of secondary school teachers and public expenditures on education passes the test. It is this set that is used

Table 9—Instrumental variable candidates for endogeneity tests

Explanatory variable	Candidate instrument	Rationale for instrument choice	Data source	Correlation between instrument and variable[a]
Access to safe water (*SAFEW*)	Annual internal renewable freshwater resources per capita	Fresh water availability is unlikely to affect child malnutrition other than through provision of safe water.	World Resources Institute (various years)	0.19 ($p = .043$)
Female secondary school enrollment (*FEMSED*)	Male gross primary school enrollment	Current male primary school enrollment unlikely to be contemporaneously correlated with malnutrition of children under five, yet to be correlated with female secondary school enrollment through the value placed on education and through its availability.	UNESCO 1998	0.55 ($p = .000$)
	Secondary school teachers per capita	Number of teachers available per person directly constrains the ability of parents to send their children to secondary school. However, could also affect child nutrition through male enrollment.	UNESCO 1998. Population data from World Bank 1997a	0.80 ($p = .000$)
	Public expenditures on education as a percentage of GNP	Public investment in education is positively correlated with the availability of educational facilities and teachers, which directly constrains the ability of parents to send their children to secondary school. However, could also affect child nutrition through male enrollment.	UNESCO 1998	0.29 ($p = .000$)
Female-to-male life expectancy ratio (*LFEXPRAT*)	Percent of births attended by health staff	Births attended by health staff are likely to be positively correlated with female life expectancy through reduced maternal mortality, yet the nutritional status of surviving children may not be affected.	UNICEF various years. World Bank 1997a	0.39 ($p = .000$)

(continued)

Table 9—Continued

Explanatory variable	Candidate instrument	Rationale for instrument choice	Data source	Correlation between instrument and variable[a]
Per capita dietary energy supply (*DES*)	Arable land per capita	Land availability is a constraining factor in agricultural production; however, it could affect child malnutrition by raising incomes from nonfood production.	FAO 1998. Population data from World Bank 1997a	−0.10 (p = .17)
	Land under cereal production per capita	Land employed as an input into cereal production raises food production. May affect child malnutrition other than through *DES* by raising incomes.	FAO 1998. Population data from World Bank 1997a	−0.19 (p = .014)
	Fertilizer use per hectare of arable land	Fertilizer use increases agricultural yields. May affect child malnutrition other than through *DES* by raising incomes or causing illness in children due to leakage of contaminants into water tables.	FAO 1998	0.49 (p = .000)
	Irrigated land per capita	The use of irrigation increases agricultural yields; however, it could affect child malnutrition other than through *DES* by raising household incomes.	FAO 1998	0.20 (p = .009)
Per capita GDP (*GDP*)	Real investment share of *GDP*	As per Pritchett and Summers 1996.	World Bank 1997a, 1998a	0.31 (p = .000)
	Foreign investment share of *GDP*	As per Pritchett and Summers 1996.	World Bank 1997a, 1998	0.25 (p = .001)
	Economic openness measure	Economic openness may improve national income but not otherwise affect child malnutrition.	Heston and Summers 1998	0.07 (p = .367)
Democracy (*DEMOC*)	No candidate identified	. . .	. . .	. . .

[a] Pearson correlation coefficient. If the *p*-value (given in parentheses) is greater than 0.1, the correlation is considered to be statistically insignificant.

Table 10—Results of endogeneity tests

Potentially endogenous explanatory variables	Instrumental variable set (1)	Number of observations (2)	Relevance[a] (3)		Overidentification[b] (4)		Hausman-Wu[c] (5)	
			F-statistic	Test passed?	χ^2 statistic	Test passed?	*t*-statistic	Test passed?
Access to safe water (*SAFEW*)	Water resources	94	3.4*	Yes	. . .	. . .	1.2[d]	Yes
Female secondary school enrollment (*FEMSED*)	Male primary school enrollments, public expenditures on education	152	1.0	No	. . .	. . .	. . .	Not performed
	Male primary school enrollments, secondary school teachers per capita	136	6.0***	Yes	3.40	No	. . .	Not performed
	Secondary school teachers per capita, public expenditures on education	119	4.5**	Yes	0.11	Yes	−0.97	Yes
Female-to-male life expectancy ratio (*LFEXPRAT*)	Birth attendance by health staff	92	0.6	No	. . .	. . .	. . .	Not performed
Per-capita dietary energy supply (*DES*)	Land in cereal, fertilizer use, irrigated land	163	2	No	. . .	. . .	. . .	Not performed
	Fertilizer use, irrigated land	177	3.1**	Yes	0.71	Yes	1.5	Yes
Per capita GDP (*GDP*)	Investment share and foreign investment share of *GDP*	164	8.9***	Yes	0.35	Yes	−0.27	Yes

Notes: These tests are only performed for the fixed-effects model specifications, with quadratic terms representing nonlinearities.

[a] The null hypothesis is that the instrument set z in a regression of the potentially endogenous variable on the exogenous variables and z is not significant.
If F is greater than the critical value of the F-distribution for 1 percent (***), 5 percent (**), or 10 percent (*) significance tests, then the null hypothesis is rejected.

[b] The null hypothesis is that the model is correctly specified (the instruments should not be included in the list of explanatory variables) and the instruments z are uncorrelated with the error term in the *CHMAL* equation. The χ^2 statistic is equal to $N \times R^2$, where N is the number of observations, and R^2 is from a regression of the predicted residuals from two-stage least squares estimation of the original *CHMAL* regression on the exogenous variables plus z. This test can only be performed when there is more than one instrument available for the variable being tested. It is not possible to perform the test using the nonlinear (quadratic) specifications because *DES* and *GDP* are too highly correlated with their squares. The test results reported are for the associated linear models. This assumes that if the instruments for the variables pass the test in the linear models, then they are uncorrelated with the error term in the nonlinear models.

[c] The null hypothesis being tested is that the instrumental variable and fixed-effects estimates are different, indicating endogeneity of the variable. The null hypothesis is rejected if the predicted residuals from a regression of the endogenous variable on the exogenous variables and instruments are insignificant when included in a regression of *CHMAL* on all explanatory variables.

[d] This t-statistic is corrected using a procedure laid out in Haddad et al. 1995. The correction is not needed for the other t-statistics because the test was passed using the uncorrected statistic (the correction reduces the size of the t-statistic).

for the Hausman-Wu test. For *DES* and *GDP* the test is undertaken for the linear models in columns (3) and (4) of Table 6.[31] Both sets of instruments easily pass the test: the null hypothesis that the instruments should not be included in the list of original explanatory variables and are not correlated with the error term in the *CHMAL* equations is not rejected. Therefore, it is assumed that the instrument sets satisfy these conditions for the nonlinear model as well, and that they are valid for performing the Hausman-Wu test.

The variables *SAFEW, FEMSED*, *DES*, and *GDP* all pass the Hausman-Wu test. The *t*-statistics on η in equation (12) (reported in column 5) are all statistically insignificant.[32]

The above test results indicate that (1) these variables are likely not endogenous, (2) the direction of causality runs from the variables *to* child malnutrition (and not vice versa), and (3) the fixed-effects (FE) estimates are not seriously plagued by measurement error problems for the variables. In light of the results, one can proceed under the assumption that the FE estimates are as accurate as possible given current data constraints. Since *SAFEW*, *DES*, and *GDP* are the variables for which there is most concern about reverse causality and (in the case of *SAFEW*) measurement error, the more efficient FE estimates are used rather than the IV estimates for the remainder of this analysis. In addition, that the estimations are based on a sound conceptual framework (Figure 1) and are undertaken with respect to changes over time in the variables provides further assurance that a causal, rather than merely associative, relationship between child malnutrition and the explanatory variables has been identified.

Hausman test for fixed-effects versus random effects (RE). As discussed in Chapter 4, FE estimates are preferred to RE estimates. Here the results of a Hausman (1978) test are given for information only. The test evaluates the null hypothesis that the country-specific effects and the regressors are correlated, in which case RE estimation is inappropriate. The null is rejected (p = .39), indicating that the assumption of no correlation between the effects and the regressors is correct, and RE estimation would be a valid procedure. For the interested reader, a comparison of the FE and RE estimates for the underlying-determinants quadratic model is presented in Appendix Table 30.

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[31] The test is not performed using the quadratic model because *DES* and *GDP* are too highly correlated with their squares, such that the test's power is diminished. For the interested reader's information, a relevance test for *DES* and *DES*-squared using an instrument set made up of fertilizer use, irrigated land, and these variables squared is not passed (p=0.163 for *DES*, p=0.11 for *DES*-squared). The overidentification test using this instrument set gives a p-value of 0.87.

[32] An attempt was made to undertake the tests for multiple independent variables. However, the sample sizes for the tests proved to be too small for most combined instrument sets. The only variables for which sufficient data exist to perform a dual test are *DES* and *FEMSED*. Two instrument sets passed the relevance and overidentification tests for the variables. Using the first set (fertilizer use, irrigated land, male primary enrollments, and public education expenditures), the Hausman-Wu test was passed when a 5 percent significance level criterion was employed, but not when a 10 percent criterion (more stringent) was employed (p=.07, n=152). For the second instrumental variable set (in which secondary school teachers replaces education expenditures), the test was passed, employing the 10 percent level criterion (p=.11, n=136). The test statistics are uncorrected. If they were corrected, the p-values would be even higher, giving added support to the finding that *FEMSED* and *DES* are not endogenous in the fixed-effects *CHMAL* equation.

Interpretation of the Parameter Estimates. Returning to the preferred estimates in column (3) of Table 7, the coefficients on the first three of the hypothesized underlying-determinant variables are statistically significant and negative. Increased access to safe water, increased education of women, and increased relative status of women all work to reduce prevalences of child malnutrition in developing countries, while increased quantities of food available at a national level do so as well. The strength of their effect declines as they increase. According to the data in the sample, they have no effect after a DES level of about 3,120 kilocalories.

Consider next the basic-determinant results in column (4). The coefficient on *DEMOC* is negative and statistically significant, suggesting that increased democracy serves to reduce child malnutrition in developing countries. As indicated by the statistically significant and negative coefficients on the first two segments of the GDP linear spline, increased national incomes per capita also work to reduce child malnutrition. The strength of the effect declines, however, as they increase. After a level of about $4,725, they no longer contribute to reductions in child malnutrition.

The estimation results in Table 8 clarify the means through which *GDP* and *DEMOC* affect child malnutrition. The coefficient on *GDP* in all equations is significant and positive. The coefficient on *GDP*-squared is significant and negative. The results suggest that per capita national income is probably an important resource base for investment—both public and private—in health environments, women's education, women's relative status, and food availabilities. However, the impact of incremental increases in national income tends to decline as incomes rise (as reflected in both quadratic and spline estimation results when *CHMAL* is the dependent variable). The coefficient on *DEMOC* is significant and positive in the *SAFEW* and *DES* equations. This result implies that democratic governments are more likely to direct their budgets to improvements in health environments and food availabilities. They are not more likely to direct public resources toward women's education or to women vis-à-vis men.[33]

How substantial, in a practical sense, are the estimated effects of the determinants on child malnutrition and how do they compare across determinants? In making such comparisons, again, it is important to consider the underlying- and basic-determinant variables separately since the determinants lie at different levels of causality.

To start with the underlying determinant variables, Table 11, column (2), reports elasticities derived from the coefficient estimates of the FE basic- and underlying-

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[33] The *GDP* coefficient(s) in the basic-determinant model(s) captures both the indirect effect of per capita national income on *CHMAL* and any direct effects that may exist. The value of the total differential of *CHMAL* with respect to *GDP* captures both effects. For the quadratic specification, at the sample mean the total differential is –0.0076 (calculated from Table 7, column 2). The value of the indirect effects of *GDP* on *CHMAL* through the underlying determinants is –0.006 (calculated from the coefficients in Table 7, column 1 and Table 8, columns 1–4). The small difference between the two gives further evidence that *GDP* mainly has its effects on child malnutrition through the underlying determinants. The similar comparison for *DEMOC* indicates that democracy most likely has effects on *CHMAL* through other means than the underlying determinants. For the quadratic specification, the value of the total differential of *CHMAL* with respect to *DEMOC* is –1.45. The value of the indirect effects through the underlying determinants is –0.55, about one-third of the total.

Table 11—Elasticities and related statistics for interpreting the strength of the effects on child malnutrition

Variable	Sample (or segment) mean (1)	Elasticity evaluated at sample mean[a] (2)	Developing-country range[b] (3)	Increase in variable needed to reduce prevalence of child malnutrition by percentage point[c] (4)	Number in (4) as a percent of developing-country range (5)
Underlying determinant variables					
Access to safe water (*SAFEW*)	56.2	−0.174	1 – 100	13.1	13.2
Female secondary school enrollment (*FEMSED*)	33.8	−0.302	0.5 – 100	4.6	4.6
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.0624	−3.092	0.97 – 1.12	0.0139	9.3
Per capita dietary energy supply (*DES*)	2,360	−0.949	1,522 – 3,605	101	4.9
$DES \leq 2,300$	2,106	−1.150	. . .	59	2.8
$2,300 < DES \leq 3,120$	2,613	−0.343	. . .	425	20.4
$DES > 3,120$	3,230	0	. . .	. . .	. . .
Basic determinant variables					
Per capita GDP (*GDP*)	2,306	−1.26	300 – 8,612	74.1	0.89
$GDP \leq 800$	645	−0.740		23	0.3
$800 < GDP \leq 4,725$	2,102	−0.605		150	1.8
$GDP > 4,725$	5,867	0.329		. . .	. . .
Democracy (*DEMOC*)	3.5	−0.181	1 – 7	0.79	13.1

Note: The numbers in column (5) provide a scale-neutral measure of the strength of impact of each variable, which allows comparison across the variables. The lower the number, the greater the strength of impact of the variable.

[a] Estimated percent change in *CHMAL* resulting from a 1 percent increase in the explanatory variable based on estimates of Table 8, columns (3) and (4). The segment elasticities for *DES* and *GDP* are evaluated at the variable and *CHMAL* means for the data falling within the segments.

[b] The end points of the developing-country ranges are for the following countries and years (minimum, maximum): *SAFEW* (Gabon 1970; Barbados 1990s), *FEMSED* (Mauritania 1970; Bahrain 1993); *LFEXPRAT* (Nepal 1975, maximum: Brazil 1996 and El Salvador 1993. Note that these numbers are only based on this study's sample and the maximum value for the sample, that of 1.15 for El Salvador in 1988 is excluded); *DES* (Ethiopia 1977, Turkey 1995); *GDP* (Ethiopia 1992; Chile 1995); *DEMOC* (see Table 3 for examples from this study's sample).

[c] Calculated as 1 divided by the regression coefficients of Table 7, columns (3) and (4).

determinant child malnutrition regressions. These numbers give the percentage of reduction in the prevalence of developing-country child malnutrition that can be expected from a 1 percent increase in each variable.[34] Among the underlying-determinant variables, by far the largest reduction in the child malnutrition prevalence—3.1 percent—is predicted to come from a 1 percent increase in the ratio of female-to-male life expectancy. This amounts to a decline of 0.8 percentage point in the sample mean prevalence of 24.6 percent, about two-and-a-half times the annual decline in the last decade. The expected effect is thus quite large. Per capita *DES* has the next highest elasticity, at –0.95. The elasticity for the first segment of the *DES* spline function is even higher, while that for the last is zero. The elasticity of *FEMSED* is –0.3. That of *SAFEW* is the lowest among the underlying-determinant variables, at –0.174.

Compared to the elasticities of *LFEXPRAT* and *DES* (for the full sample), those of *FEMSED* and *SAFEW* are quite small. However, the variables are all measured in different units. In comparing the strengths of their effects, attention must be paid to the range of numerical values each actually takes on. These ranges, based on the minimum and maximum values observed among developing countries over the period 1970–95, are given in Table 11, column (3). The ranges for *SAFEW* and *FEMSED* are roughly equal, at about 1 to 100. The comparison of their elasticities is thus straightforward. However, it is difficult to compare the variable *SAFEW* with *LFEXPRAT*; the latter takes on values from 0.97 to 1.12. A 1 percent increase in *SAFEW* over the sample mean would raise it from 56.2 percent to 56.8 percent, quite a small change in terms of its 1 to 100 percent range (only 0.6 of a percent of the range). A 1 percent increase in the variable *LFEXPRAT* over its sample mean (1.062 to 1.071), by contrast, represents 6 percent of its entire range. Thus, while the variable *LFEXPRAT* has a large elasticity and *SAFEW* a small one, it would take quite a large increase in the former, compared with the latter, to raise the variable by 1 percent.

Taking this scaling factor into account, the relative strengths of impact of the variables can be seen from the standpoint of how much an increase in each would be required to bring about the same change in child malnutrition. For example, how much would each have to be increased (holding the others constant) to reduce the malnutrition prevalence by 1 percentage point? These increases are given in Table 11, column (4). They are translated into "scale neutral" numbers that are comparable across variables by calculating each number as a percent of its range (column 5).

A 13.1 percentage-point increase in population with access to safe water would be required to bring about a 1 percentage-point reduction in the prevalence of child malnutrition. This represents 13.2 percent of the variable's range. By contrast, the required increase in female secondary school enrollments is only 4.6 percentage points, representing only 4.6 percent of its range. Thus the required increase in safe water access to bring about the same reduction in child malnutrition is much higher than the

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[34] Full sample elasticities for *DES* and *GDP* are estimated using (1) a weighted average of regression coefficients for each of the three spline segments, where the weights are the proportion of the sample data points falling into each segment; and (2) sample variable means. Segment-specific elasticities are calculated using segment-specific regression coefficients and segment-specific variable means.

required increase in female school enrollments. The required increase in per capita *DES* for the full sample (101 kilocalories) is 4.9 percent of its range; that of the female-to-male life expectancy ratio (0.0134) is 9.3 percent of its range. Therefore a rough ranking of the underlying determinant variables in terms of their potency in reducing child malnutrition is women's education (greatest potency), followed closely by food availability, followed by women's relative status in third place, and safe water access in fourth place. Note that for countries falling into the low DES range (≤2,300) food availability is ranked first and women's education second. For countries falling into the medium and high (>3,120) DES ranges, however, women's education is ranked first and food availability last. The policy implications of these rankings will be drawn out more fully in Chapter 8.

For the basic determinant variables, national income appears to be a more potent force for reducing child malnutrition than is democracy. The full sample elasticity of GDP per capita, at –1.26, is much higher than that of *DEMOC* (–0.18). The required increase in GDP to reduce the child malnutrition prevalence by one percentage point is $74. This is a very small proportion of the variable's range, less than 1 percent. By contrast, a very large change in democracy would be required to bring about the same change, an increase in the index of 0.8 points (13 percent of its range). The stronger impact of national income than democracy holds even for the medium GDP segment (between $800 and $4,725). For the high GDP group ($4,725), however, democracy prevails as the most potent basic determinant.

Differences Across Regions. Past studies suggest that there may be differences across the developing regions in the determinants of child malnutrition or in the magnitude of their effects, especially for South Asia (see Chapter 3). For the underlying-determinants FE model, a Chow *F*-test of parameter stability across the regions does not reject the null hypothesis that all the coefficients are identical across regions.[35] While some regional differences probably do exist, they are not strong enough to detect given the data in the sample. Thus, it is assumed that the underlying-determinant parameter estimates given in Table 7, columns (3) and (4) apply to all of the regions.

While from a structural standpoint the child malnutrition-DES relationship does not differ substantially across the regions, the regions do differ greatly in terms of the *levels* of their per capita DESs. Because the strength of this variable depends on its level, the regions thus differ greatly in the strength of impact of *DES* on child malnutrition. Table 12, column (2), reports estimates of the *DES* regression coefficients for each developing-country region.[36] Corresponding to their low per capita DESs over the study period, the effects for Sub-Saharan Africa and South Asia are the highest in

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[35] The test statistics for the hypothesis that the slope coefficients are equal across all regions is F=1.15, which is not even significant at the 10 percent level. The highest F-statistic for the five tests of the hypothesis that individual regions differ is 1.54 (for South Asia), which is also not significant.

[36] These coefficients are calculated as a weighted average of the segment parameter estimates, where the weights are the proportion of the sample data points of the region falling into each segment.

Table 12—Estimated child malnutrition regression coefficients for per capita dietary energy supply and per capita gross domestic product by region, 1970–95

Region	Per capita dietary energy supply		Per capita gross domestic product	
	Mean (1)	Coefficient (2)	Mean (3)	Coefficient (4)
South Asia	2,187	−0.0133	863	−0.0255
Sub-Saharan Africa	2,164	−0.0140	879	−0.0222
East Asia	2,595	−0.0085	1,874	−0.0090
Near East and North Africa	3,058	−0.0019	2,527	−0.0067
Latin America and the Caribbean	2,647	−0.0069	4,740	−0.0040
Full sample[a]	2,360	−0.0099	2,306	−0.0135

Notes: The regression coefficients are calculated using the country fixed-effects coefficient estimates of Table 7, columns (3) and (4). They are calculated as a weighted average of the segment coefficients, where the weights are the proportion of the sample data points of the region falling into each segment.

[a] While the regional means are population-weighted, the full sample means are not (see Table 3).

magnitude, both at about −0.01. The other regions have substantially higher DESs per capita, and thus their coefficient estimates are much lower in magnitude.

For the basic-determinants FE model, the Chow *F*-test for parameter stability rejects the null hypothesis that all the coefficients are identical across regions. The test results suggest that there are significant structural differences across the regions in the effects of national income or democracy or both and, in particular, that South Asia differs fundamentally from the others.[37]

As for food availability, the effect of per capita national incomes on child malnutrition for any region depends on its level. Table 12 reports the estimated regional per capita GDP regression coefficients (column 4). In South Asia and Sub-Saharan Africa, which had the lowest GDPs per capita over the study period, the effect of national income is relatively strong. It is much weaker for East Asia, NENA, and LAC.

Note that the regression coefficients reported in Table 12 reflect the regions' average DES and GDP positions as they stood over 1970–95. In Chapter 8, regional differences are discussed in the context of the regions' current positions, which differ substantially from the 25-year study period.

The final clue as to whether there are substantial regional differences in the causes of child malnutrition lies in the magnitudes of the country FE terms included in the regression equations. These terms represent the effects of factors that do not change very

[37] For the hypothesis that the slope coefficients are equal across all regions, F=3.09, which is significant at the 1 percent level. The test statistic for the null hypothesis that South Asia differs from the others is F=6.4, which is significant at the 1 percent level. The test statistic for the null hypothesis that LAC differs from the others is F=3.8, which is significant at the 5 percent level. Those for all other regions are statistically insignificant.

much over time (over 13-year periods). A very clear result from the analysis is that the influence on child malnutrition of these unobserved factors is much stronger for South Asia than for the other regions. The mean of the FE coefficients in the underlying-determinants model is 9.6; the mean for South Asia is far above that for the sample and the other regions, at 33.3.[38]

Estimation Results for Dynamic Models

Tables 13 and 14 present the results of the dynamic estimations for the basic and underlying determinant models, respectively. Consider first the OLS-estimated basic-determinant results (Table 13, column 1). Controlling for current levels of per capita GDP and democracy, child malnutrition in the previous period is estimated to have a highly statistically significant effect on current levels of child malnutrition. This result suggests a strong link between current and past levels of child malnutrition, either through cumulative effects on children over time or intergenerational linkages. The OLS estimates for the underlying determinants (Table 14, column 1) also indicate a strong positive relationship between current and past child malnutrition. *SAFEW* is the only other variable whose parameter estimate is statistically significant.

In the country FE estimates for both basic- and underlying-determinant models, the coefficient on lagged *CHMAL* is not statistically significant. Note, however, that the t-statistics on the coefficients are fairly high. The FE estimations require that three data points in time be available for any country included: the current observation, the lagged observation, and a twice-lagged observation (as an instrumental variable). Thus the estimations were limited to 36 countries (54 data points). Only as more data become available will it be possible to determine in a robust manner whether the relationship is statistically significant.

Overall, this analysis indicates, but is not able to give strong evidence in support of, the possibility that child malnutrition may have substantial “feedback” effects. The coefficient estimates on lagged child malnutrition reported in Tables 13 and 14 range from a low of 0.28 to a high of 0.838. If these estimates can be verified, they indicate that a 1 percentage-point increase in the prevalence of child malnutrition today contributes to an increase of between 0.3 and 0.8 percentage points in child malnutrition in the future, regardless of the current state of safe water access, women’s education, women’s status, food availability, national income, and democracy.

[38] The average FE coefficients for the other regions are Sub-Saharan Africa, 6.3; East Asia, 19.3; NENA, 2; and LAC, 5.7 percentage points.

Table 13—Child malnutrition dynamic regressions, basic-determinant variables

Variable	Ordinary least squares (1)	Country fixed effects: Without time trend and initial conditions (2)	Country fixed effects: With time trend and initial conditions (3)
Lagged child malnutrition	.76 (19.3)***	.290 (1.41)	.454 (.941)
Per capita GDP (*GDP*)	–.001 (2.92)***	–.745 (1.0)	– .0016 (.95)
Democracy (*DEMOC*)	–.931 (2.64)***	–.0008 (.61)	–1.27 (1.32)
Time trend (t)	. . .	. . .	.52 (1.33)
$t \times GDP_0$	. . .	. . .	.0006 (.87)
$t \times DEMOC_0$	. . .	. . .	–.903 (1.57)
R^2	.856	.0605	.1102
Number of countries	63	36	36
Number of observations	116	54	54

Notes: The dependent variable is the prevalence of underweight children under age five. Absolute values of t-statistics are given in parentheses. The fixed-effects models are estimated with the constant term suppressed. Thus the R^2 statistic measures the proportion of variability in the dependent variable about the origin explained by each regression. It cannot be compared to the R^2 statistics for the previous models since they included intercept terms. In the fixed-effects model, first-differenced lagged child malnutrition is instrumented with child malnutrition lagged two periods to correct for correlation of the term with the fixed-effect component of the error term.

*** Significant at the 1 percent level.

Table 14—Child malnutrition dynamic regressions, underlying-determinant variables

Variable	Ordinary least squares: Without initial conditions (1)	Country fixed effects: Without time trend and initial conditions (2)	Country fixed effects: With time trend and initial conditions (3)
Lagged child malnutrition	.756 (19.0)***	.284 (.924)	.629 (1.31)
Access to safe water (*SAFEW*)	–.074 (2.29)**	.021 (.27)	–.011 (.11)
Female secondary school enrollment (*FEMSED*)	–.042 (1.3)	.014 (.36)	.009 (.18)
Female-to-male life expectancy ratio (*LFEXPRAT*)	–32.2 (1.4)	–165 (1.87)*	–148 (1.33)
Per capita dietary energy supply (*DES*)	–.0012 (.60)	–.0083 (1.3)	–.009 (1.14)
Time trend (*t*)	. . .	. . .	–.199 (.42)
$t \times SAFEW_0$	. . .	. . .	–.089 (1.33)
$t \times FEMSED_0$	. . .	. . .	.014 (.21)
$t \times LFEXPRAT_0$	. . .	. . .	–8.21 (1.03)
$t \times DES_0$	. . .	. . .	.007 (1.84)*
R^2	.854	.1472	.2097
Number of countries	63	36	36
Number of observations	116	54	54

Notes: The dependent variable is the prevalence of underweight children under age five. Absolute values of *t*-statistics are given in parentheses. The fixed-effects models are estimated with the constant term suppressed. Thus the R^2 statistic measures the proportion of variability in the dependent variable about the origin explained by each regression. It cannot be compared to the R^2 statistics for the previous models since they included intercept terms. In the fixed-effects model, first-differenced lagged child malnutrition is instrumented with child malnutrition lagged two periods to correct for correlation of the term with the fixed-effect component of the error term.

* Significant at the 10 percent level.

** Significant at the 5 percent level.

*** Significant at the 1 percent level.

CHAPTER 6

How Has Child Malnutrition Been Reduced in the Past? A Retrospective

The approximate reductions in the prevalence of child malnutrition that took place between 1970 and 1995 for the developing countries as a group and for individual regions are summarized in Table 1. How were these reductions brought about? In this chapter, based on the regression analysis of the last, the contributions of improvements in health environments, women's education, women's status relative to men's, national food availability (underlying-determinant variables), national incomes, and democracy (basic-determinant variables) are explored.

To answer the question, the FE parameter estimates of Table 7 (columns 3 and 4) are used to formulate a predicting equation for the change in child malnutrition prevalence over 1970–95. Using the underlying-determinants model as an example, the base predicting equation (from equation 9) is

$$C\hat{M}_t = 140 - .076\,SAFEW_t - .220\,FEMSED_t - 71.8\,LFEXPRAT_t$$
$$- .017\,DES1_t - .002\,DES2_t + 0.0\,DES3_t + \hat{\mu}, \tag{19}$$

where *DES*1, *DES*2, and *DES*3 are the segments of the *DES* linear spline and is the FE term. This latter term is wiped out using a first-difference transformation as follows:

$$\Delta C\hat{M} = C\hat{M}_{1995} - C\hat{M}_{1970} = -.076\,\Delta SAFEW - .220\,\Delta FEMSED$$
$$- 71.8\,\Delta LFEXPRAT - .017\,\Delta DES1 - .002\,\Delta DES2 + 0.0\,\Delta DES3. \tag{20}$$

Each variable's absolute and percentage contributions to the total change are then calculated.[39] The absolute and percentage contributions, respectively, of *SAFEW* for example, are

$$-.076\,\Delta SAFEW \text{ and } \frac{-.076\Delta SAFEW \times 100}{\Delta CM}. \tag{21}$$

For information on how much each variable has actually changed over the period for the sample, the data set is expanded to include all available data for the variables at six points in time: 1970, 1975, 1980, 1985, 1990, and 1995. Variable means for each of these years as well as their total change over the study period are given in Table 15. Appendix Tables 25–29 contain the information by region. The estimated contribution of the proxy measure for each variable is employed to estimate its contribution. For example, the contribution of increases in per capita *DES* is used to estimate the contribution of national food availability.

The upper panel of Table 16 reports the results for the underlying-determinant variables over 1970–95. The total predicted contribution for the sample is a reduction of 15.9 percentage points (row 4). The number is quite close to the 15.5 percentage-point reduction estimated for all developing countries in Table 1.[40]

Figure 12 summarizes the estimated percent contribution of each underlying determinant variable to the reduction in the prevalence of child malnutrition. The change in each over the period on an equivalent (100 percent) scale is also presented to aid in interpretation (Figure 13). Improvements in women's education have contributed by far the most, 43 percent. This contribution is the combined result of both the strong effect of the determinant and a fairly large increase in it over the period, as shown in Figure 13. The contribution of improvements in health environments has also been substantial: almost 20 percent. Improvements in food availability have contributed around 25 percent of the reduction in child malnutrition, not only because the effect of this variable is strong but also because increases have been substantial, rising from 2,092 kilocalories per capita in 1970 to 2,559 in 1995. The

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[39] This procedure is similar to that undertaken in the estimation of "population attributable risk" (common in epidemiology) in which information on the risk of contracting a disease (such as lung cancer) from exposure to risk factors (such as smoking) is combined with information on the prevalence of the risk factor to determine the number of cases of the disease that are associated with the risk factor (Kahn and Sempos 1989).

[40] Two sources of differences in the "actual" and predicted numbers are (1) any differences between the study sample and the developing countries as a whole in terms of the etiology of child nutrition; and (2) a restricted data set, in terms of years covered, which is employed in the regression equations due to the need to match data on the explanatory variables with the particular years for which underweight data are available in the former. That the two numbers are close indicates that the sample is representative of the developing countries as a whole. It also gives supporting evidence that the model provides a good predicting equation for underweight in the historical period covered. The predicted child malnutrition values for individual regions can also be compared with the numbers reported in Table 1. They are quite close for Sub-Saharan Africa, East Asia, and Latin America and the Caribbean. However, the predicted value is 28 percent higher than the actual for South Asia; it is 100 percent lower than the actual for the Near East and North Africa region.

Table 15—Underlying-determinant and basic-determinant variable means, 1970–95

Variable	1970 (1)	1975 (2)	1980 (3)	1985 (4)	1990 (5)	1995 (6)	Absolute change, 1970–95 (7)	Average annual change, 1985–95 (8)
Underlying-determinant variables								
Access to safe water (percent)	30.2	45.4	52.4	60.7	69.9	70.3	40.1	0.96
Female secondary school enrollment (percent)	15.6	25.4	28.4	30.6	36.4	46.6	31.0	1.6
Female-to-male life expectancy ratio	1.022	1.026	1.033	1.040	1.045	1.048	0.024	0.0008
Female life expectancy (years)	55.2	58.5	60.4	63.5	65.3	66.0	10.79	0.25
Male life expectancy (years)	54.0	56.9	58.5	60.8	62.4	63.0	9.04	0.22
Per capita dietary energy supply (kilocalories)	2,092	2,089	2,226	2,380	2,472	2,559	467	17.9
Basic-determinant variables								
Per capita GDP (US$ PPP)	1,011	1,163	1,361	1,378	1,673	2,121	1,111	44.8
Democracy (1 = least democratic)	2.85	2.99	3.75	3.31	3.24	2.71	−0.14	−0.06

Notes: These data are population-weighted. They are estimated using data for the countries in the data set only (Comoros was dropped from the sample due to the absence of population data). In some cases where data were not available for a sample country for a particular year, extrapolations were undertaken.

Table 16—Estimated contributions of underlying- and basic-determinant variables to changes in the prevalence of child malnutrition, by region, 1970–95

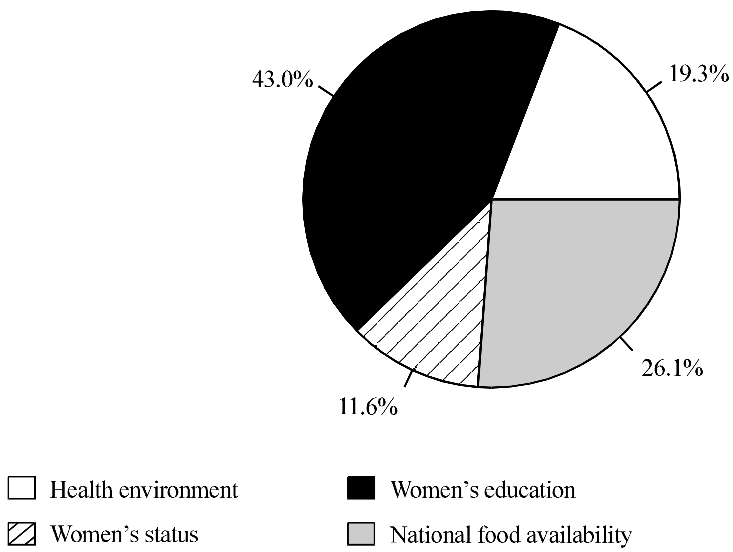
Variable	All regions (1)	South Asia (2)	Sub-Saharan Africa (3)	East Asia (4)	Near East and North Africa (5)	Latin America and the Caribbean (6)
	(percentage-point change in underweight rate)					
Underlying-determinant variables						
Health environment	–3.06	–4.56	–2.07	–2.74	–0.45	–1.80
Women's education	–6.82	–4.61	–3.39	–9.27	–9.64	–6.98
Women's status relative to men's	–1.84	–3.85	+1.27	–1.36	+0.28	–1.65
National food availability[a]	–4.14	–3.44	–0.048	–6.11	–2.34	–0.77
Total percentage-point change	–15.9	–16.5	–4.2	–19.5	–12.4	–11.2
Basic-determinant variables[b]						
Per capita national income[a]	–7.39	. . .	. . .	. . .	. . .	. . .
Democracy	+0.18	. . .	. . .	. . .	. . .	. . .
Total percentage-point change	–7.2	. . .	. . .	. . .	. . .	. . .

Notes: The estimates in this table are obtained by multiplying the coefficients on the proxy variables for each determinant (see Table 7, columns [3] and [4]) by the change in the proxy from 1970–95. The changes are obtained from Appendix Tables 25–29.

[a] These estimates take into account the changing coefficient on the proxy variable (*DES* and *GDP*) as its level changes.

[b] As discussed in Chapter 5, the regression coefficients of the basic-determinants model cannot be applied to the regions separately due to fundamental structural differences across the regions. Thus, contributions for the basic-determinant variables are not broken down by region.

Figure 12—Estimated contributions of underlying-determinant variables to reductions in developing-country child malnutrition, 1970–95



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

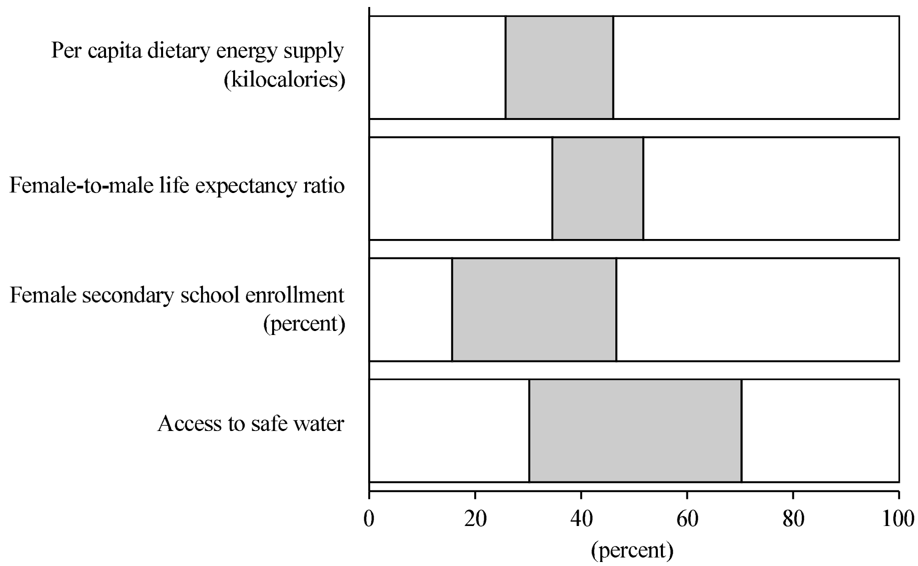
smallest contribution (12 percent) came from improvements in women's status as gauged by the female-to-male life expectancy figures. While this factor has a strong impact on child malnutrition, it has improved very little compared to the other variables (Figure 13). Together, the contributions of women's education and relative status have contributed to more than half of the 1970–95 reduction in child malnutrition in the developing countries. It can thus be surmised that much of the reduction has come from improvements in maternal and child care, confirming its critical role in the etiology of child nutrition. Some of the effect may also be working through the pathway of improved household food security.

Figure 14 traces out the contributions of the underlying-determinant variables to changes in child malnutrition prevalences for five-year intervals during the study period, starting with 1970–75 and ending with 1990–95. The change in the prevalence of malnutrition over the intervals, in percentage points, is marked on the vertical axis. The bar falls below zero when there has been an increase in a variable, which is associated with a reduction in child malnutrition. A bar value above zero indicates that there has been an increase in child malnutrition due to a reduction in the level of a variable.

There are several points to note from the figure.

- There has been a fairly steady decline in the prevalence of developing-country child malnutrition of about 3.2 percentage points every five years since the

Figure 13—Increases in underlying-determinant explanatory variables, 1970–95, on an equivalent scale of 100 percent



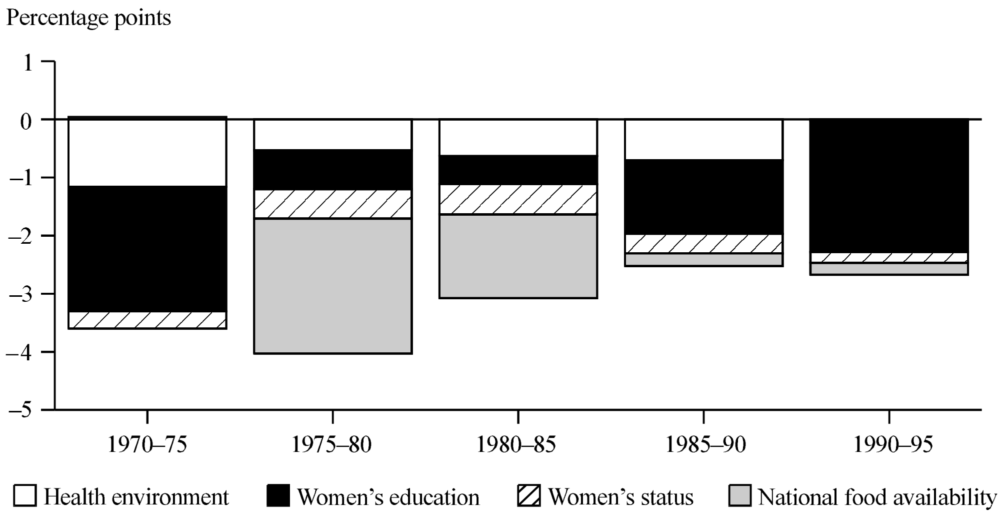
Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Notes: This figure shows the increase in each underlying-determinant variable over 1970–95 on an equivalent scale that allows comparison across variables even though they are measured in different units. Each variable is transformed by equating the minimum of its developing-country range to 0, the maximum to 100, and the in-between numbers to their relative positions on this scale. The variable ranges are given in Table 11, column (3). The shaded area in the bar for each variable starts with its 1970 transformed value and ends with its 1995 transformed value.

early 1970s. The largest reduction, 4 percentage points, came in the 1975–80 period. Since then, the reductions have been smaller.

- The contribution of improvements in health environments has declined over the 25-year period; in the early 1990s it made very little contribution.
- Women's education made its greatest contribution in the early 1970s and early 1990s. Its contribution dropped dramatically between 1970 and 1980; since then it has gradually increased. It contributed 84 percent of the total 2.7 percentage-point reduction in the underweight prevalence in the early 1990s.
- Corresponding to the world food crisis of the 1970s, food availability declined during 1970–75, leading to a slight *increase* in child malnutrition. As the Green Revolution picked up, the developing countries saw substantial increases in their food supplies. The contribution of food availability to declines in malnutrition were steady and substantial in the late 1970s and early 1980s. Despite continued increases in food availability in the late 1980s and early 1990s (see Table 15), their contribution to reductions in child malnutrition has leveled off due to a decline in strength of their impact as they have increased.

Figure 14—Changes in child malnutrition in developing countries: Estimated contributions of underlying-determinant variables, five-year periods, 1970–95

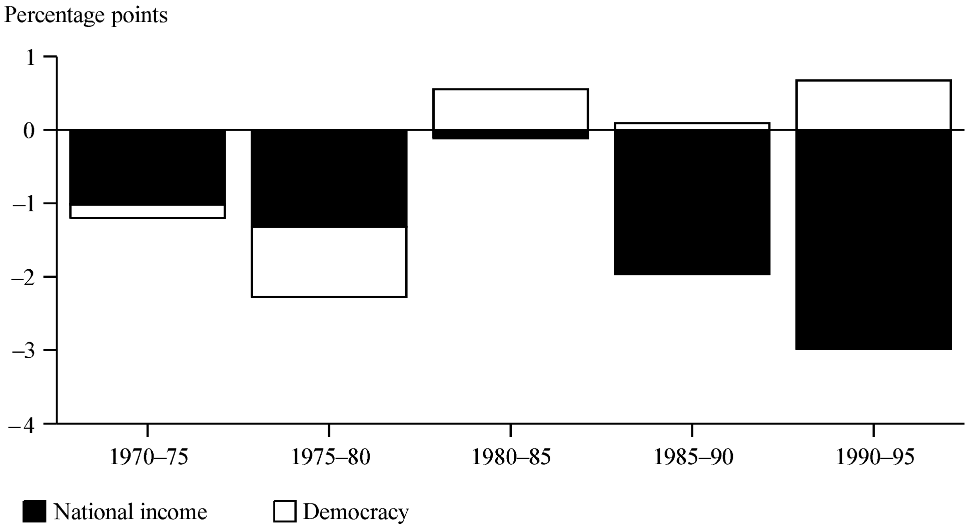


Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

- As improvements in women's status have fluctuated over the 25-year period, so too has their contribution to malnutrition reductions. The greatest contribution was made in the early 1980s; since the late 1980s it has declined considerably.

The bottom panel of Table 16 gives the contribution of the basic-determinant variables. Democracy has actually deteriorated slightly. Despite its potential positive contribution, this declining trend is associated with a slight increase in child malnutrition. Improvements in per capita national income, however, have been quite large. For the full sample of countries, per capita GDP rose from $1,011 in 1970 to $2,121 in 1995, more than doubling. This large increase, in combination with the strong influence of the variable, has facilitated an estimated 7.4 percentage-point reduction in child malnutrition. The influence of national incomes in reducing malnutrition throughout the developing world over the 25-year period since 1970 has thus been quite strong. Figure 15 breaks the two variables' contributions down into five-year periods. While democracy made positive contributions in the 1970s, since then its decline has put a drag on child nutrition improvements. Aside from the early 1980s, the contribution of national income has been steadily increasing since the 1970s. Its greatest contribution came most recently: in the 1990–95 period alone it contributed to a 3 percentage-point decline in the prevalence of malnutrition.

Figure 15—Changes in child malnutrition in developing countries: Estimated contributions of basic-determinant variables, five-year periods, 1970–95



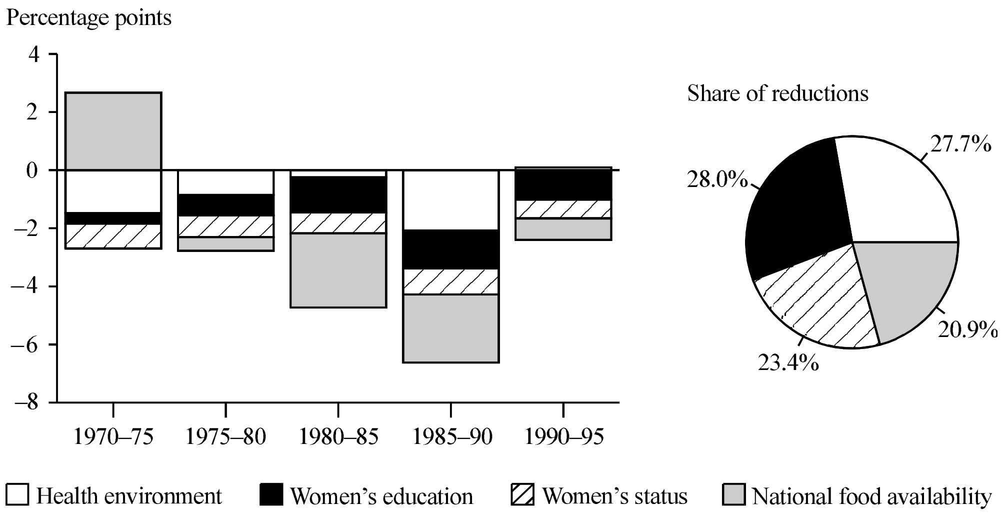
Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Since there are fundamental differences across the regions in the strength of impact of the basic-determinant variables, precise region-specific estimates of their contributions cannot be undertaken. It can be inferred, however, that the contribution of national income has been positive for all regions except Sub-Saharan Africa (where it declined). The contribution of democracy has been positive for Sub-Saharan Africa, NENA, and LAC, but negative in South Asia and East Asia.

The regions' experiences have also differed regarding the relative contributions of the underlying-determinant variables. The section on regional differences in Chapter 5 demonstrated that there are no significant differences in the functional relationships between the underlying-determinant variables and child malnutrition. Thus their contributions can be quantified using the full-sample coefficient estimates of Table 7, column (3).

The overall reduction in the prevalence of child malnutrition in South Asia for the 25-year period is estimated to be 16.5 percentage points. As illustrated in Figure 16, the greatest contributions to this reduction have come from increased education of women and improvements in health environments, at about 28 percent each. Improvements in women's relative status have accounted for about 25 percent of the reduction and improvements in food availability about 20 percent. Figure 16 shows that the factors' relative contributions have fluctuated substantially over the study period. In the early 1970s, reductions in child malnutrition from improvements in health environments, women's education, and women's relative status were completely undermined

Figure 16—Changes in child malnutrition in South Asia: Estimated contributions of underlying-determinant variables, five-year periods, 1970–95



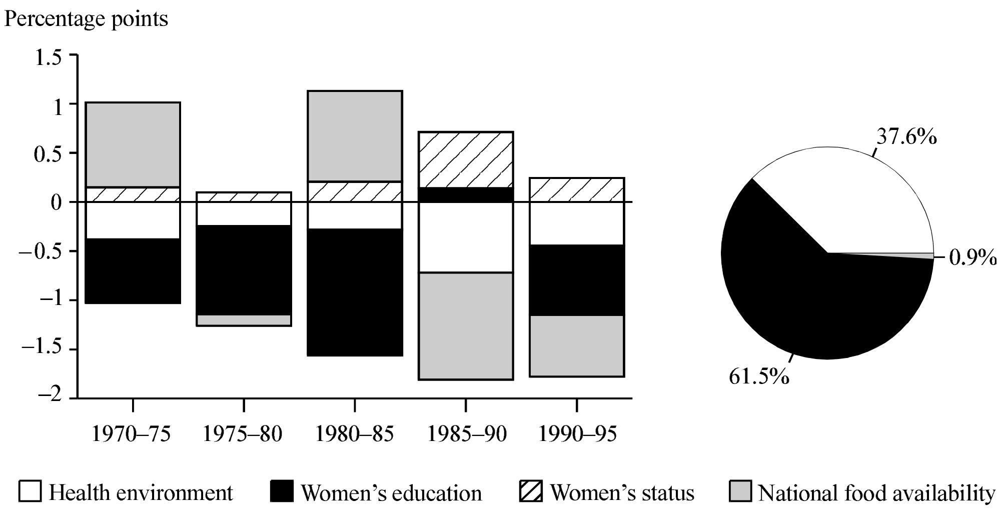
Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

by reductions in food availability. As a result, no progress was made. By the late 1970s, food availability began to improve and it contributed substantially to reductions in child malnutrition in the 1980s and early 1990s. The 1980s saw a precipitous decline in the prevalence of malnutrition in the region (over 11 percentage points) due to improvements in all of the factors. However, in the 1990–95 period, the pace of improvement has been severely curtailed by slower growth in health environment improvements and food availability.[41] While the relative status of women in South Asia continues to be the lowest of all developing-country regions (the 1995 female-to-male life expectancy ratio was 1.02), small improvements have made a steady contribution in the past 25 years.

The total reduction in Sub-Saharan Africa's child malnutrition rate over the study period is estimated to be only 4.2 percentage points. This overall net reduction masks the negative effect that deteriorations in women's relative status have posed over the study period. Figure 17 gives the percent contributions of the remaining factors to reductions in the region's prevalence of child malnutrition. The largest share of the reduction was brought about by increases in women's education, followed by

[41] The declining contribution of food availability is partially due to declining impact as food supplies increased.

Figure 17—Changes in child malnutrition in Sub-Saharan Africa: Estimated contributions of underlying-determinant variables, five-year periods, 1970–95



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

improvements in health environments. A very small contribution was made by improvements in food availability. Figure 17 gives a fuller picture of the role the underlying-determinant variables have played. Improvements in health environments have made their greatest contribution since 1985. Increased education of women made strong contributions in all periods except for the late 1980s, when it actually declined. Women's relative status has continually declined in the region since the 1970s, most precipitously after 1985. Its contribution has thus been to *worsen* child malnutrition in the region throughout the study period. Changes in food availability have played a large role overall. However, the role was not always positive. Substantial improvements in the late 1980s and early 1990s were outweighed by deteriorations, for the most part, during the 1970–85 period.

The prevalence of child malnutrition has declined the most in East Asia, about 20 percentage points. The greatest contribution to this decline came from increases in women's education, followed by improvements in food availability and health environments (Figure 18). The early 1970s witnessed a very large reduction in child malnutrition of more than 6 percentage points (Figure 18), most of which was due to increases in women's education. Progress since this period has not been as great, but it has continued steadily. The contributions of improvements in the health environment and women's relative status declined over the period and were minimal by the 1990s. Improvements in food availability have taken place at a relatively fast pace in East

Box 1

Why Has Child Malnutrition Been Rising in Sub-Saharan Africa?

Sub-Saharan Africa is the only region in which the prevalence of child malnutrition has been increasing. From 1985 to 1995, it increased from 29.9 percent to 31.1 percent (see the table below). Of the four underlying-determinant variables, only one—women's relative status as proxied by the female-to-male life expectancy ratio—was moving in the wrong direction during the period. Two others, national food availability and women's education—both of which remain at extremely low levels—were almost stagnant. In addition, national income for the region declined significantly: per capita GDP fell by $52. The decline in this important basic determinant of child malnutrition is responsible for slow progress in all of the underlying-determinant factors and a slight increase in poverty. Therefore, it seems likely that deterioration in women's relative status and per capita national income, along with stagnation in women's education and food availability, at least partially explains the deterioration in child malnutrition in the region. Other factors may be deterioration in the capacity and outreach of government services under the impact of debt and structural adjustment; the rising incidence of HIV/AIDS (Ramalingaswami, Jonsson, and Rohde 1996); and conflict (Messer, Cohen, and D'Costa 1998). The decline in the ratio of women's life expectancy to men's is puzzling. It may be because women in Sub-Saharan Africa are more vulnerable to HIV/AIDS than men are, which itself reflects women's lower status (Brown 1996; Howson et al. 1996).

Trends in the determinants of child malnutrition in Sub-Saharan Africa, 1985–95

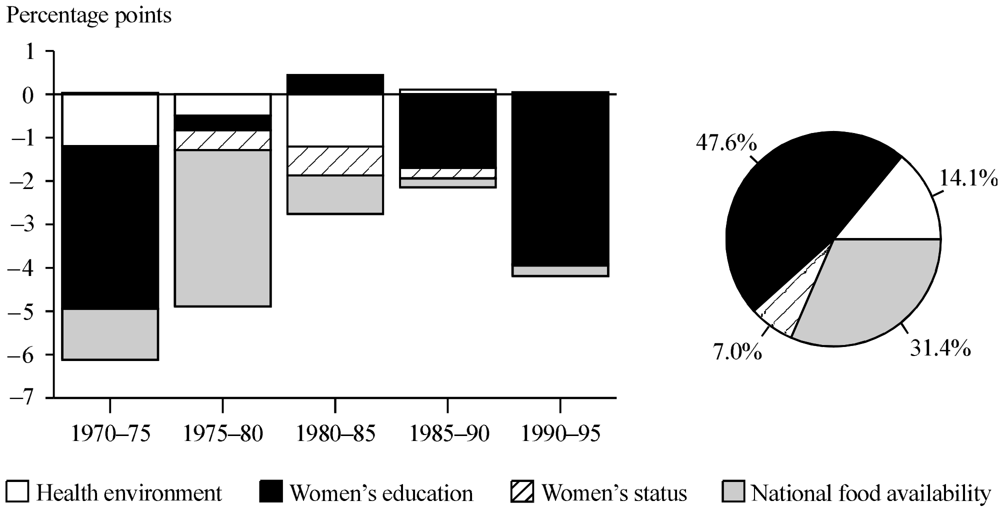
	1985	**1995**	**Percentage change, 1985–95**
Child malnutrition (percent underweight)	29.9	31.1	4.0
Access to safe water (percent)	33.5	48.8	45.7
Female secondary school enrollment (percent)	16.4	19.0	15.8
Female-to-male life expectancy ratio	1.066	1.054	–1.1
Per capita dietary energy supply (kilocalories)	2,035	2,136	5.0
Per capita national income (PPP US$)	830	778	–6.3
Democracy	2.01	2.44	21.4
Poverty (percent)[a]	38.5	39.1	1.6

Sources: Tables 1 and 26. Poverty data are from Ravallion and Chen 1996, Table 5.

Notes: With the exception of the poverty rates, these data are population-weighted means over all countries in the data set in each region. The poverty measure employs an international poverty line of $1 per person per day at 1985 power parity.

[a] Poverty figures are for 1983 and 1993.

Figure 18—Changes in child malnutrition in East Asia: Estimated contributions of underlying-determinant variables, five-year periods, 1970–95



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Asia, rising from 1,998 kilocalories per capita in 1970 to 2,720 kilocalories in 1995. Overall they have contributed to a reduction in the prevalence of child malnutrition of about 6 percentage points.

Almost all of the reduction in child malnutrition in the Near East and North Africa region has come from increases in women's education (Figure 19).[42] The state of health environments has fluctuated widely—sometimes improving, sometimes deteriorating—the net result being a very small contribution of 3.6 percent. Women's relative status deteriorated in most periods, muting child nutrition improvements. Improvements in food availability have contributed 19 percent to the reduction in child malnutrition. Although food availability has improved in all periods, its marginal impact has declined. By 1995, per capita DES had reached 3,172 kilocalories, a point past which food availability has no or minimal impact.

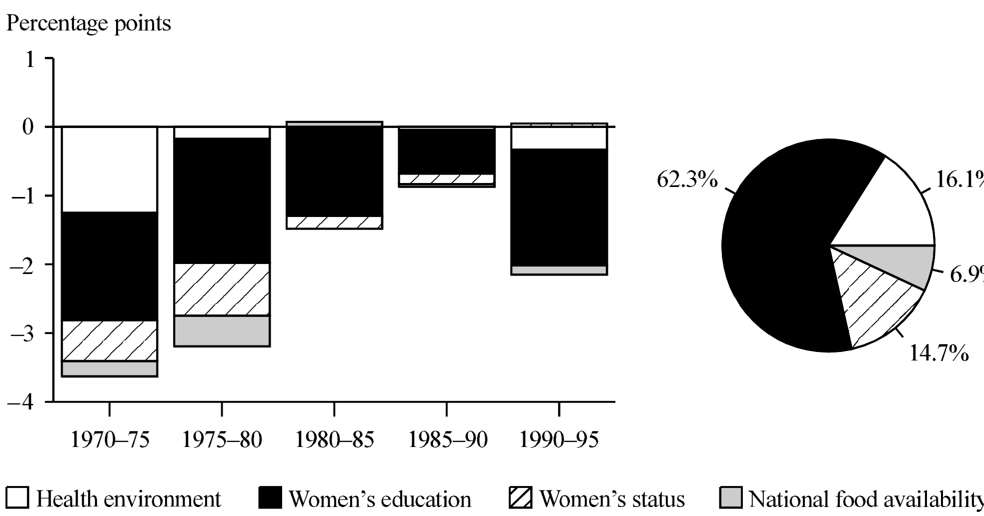
The Latin America and Caribbean region experienced an estimated 11 percentage-point reduction in child malnutrition during the period, most of which took place during 1970–80. Since then, reductions in child malnutrition have continued at a much slower pace (Figure 20). As for the other regions, the greatest contri-

[42] The results for this region should be treated with caution given that the majority of countries in the region are not represented in the sample and that the model overpredicts the total reduction in child malnutrition for it substantially (see footnote 40).

Figure 19—Changes in child malnutrition in Near East and North Africa: Estimated contributions of underlying-determinant variables, five-year periods, 1970–95

Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Figure 20—Changes in child malnutrition in Latin America and the Caribbean: Estimated contributions of underlying-determinant variables, five-year periods, 1970–95



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

bution (62 percent) came from expansions in female education (Figure 20). The contribution of improvements in health environments has steadily declined. Strong improvements in women's relative status in the 1970s were followed by small improvements in the 1980s. By the early 1990s there was a slight decline, muting the overall reduction in malnutrition of the period. Food availabilities improved in the 1970s, but declined in the early 1980s. Their contribution has been minimal since the early 1980s.

CHAPTER 7

Projections of Child Malnutrition in the Year 2020

Up to this point, this report has focused on the period 1970–95. Looking toward the next 25 years, by how much is the developing-country prevalence of child malnutrition likely to decline by the year 2020? How fast is the decline likely to take place? Which regions are likely to experience the greatest improvements? Given population growth, are the *numbers* of children who are malnourished likely to increase or decrease? Future prevalences of child malnutrition are obviously dependent on levels of effort exerted to reduce them. To answer these questions, the estimation results in Table 7, columns (3) and (4) are applied to consider three scenarios based on the projected evolution of the underlying-determinant variables over the period 1995–2020. These are a status quo or "do nothing different" scenario; a pessimistic scenario; and an optimistic scenario.

The evolution of safe water access, female secondary school enrollments, and the female-to-male life expectancy ratio under the alternative scenarios is predicted base on these variables' average annual increase over 1985–95. Per capita dietary energy supply projections are generated by IFPRI's IMPACT model (Rosegrant, Agcaoili-Sombilla, and Perez 1995).[43] The projections are based on assessments of future developments in the world food situation (including changing prices of food and changes in agricultural productivity) and various assumptions about future agricultural research investments, population growth,[44] and growth in nonagricultural incomes. The levels of each explanatory variable in 1995 and under the alternative scenarios are given in Table 17, rows (3)–(6).

The assumptions underlying each scenario are as follows.

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[43] The IMPACT model is the International Model for Policy Analysis of Agricultural Commodities and Trade. Developed at IFPRI, it is made up of a set of 35 country or regional models that determine supply, demand, and prices for 17 agricultural commodities.

[44] 1992 medium population growth rates (United Nations 1993) are employed as the basis for population projections in the IMPACT model. The projections of the numbers of children under five years of age are taken from Rosegrant Agcaoili-Sombilla, and Perez (1995).

Table 17—Projections to 2020 of the prevalence and numbers of malnourished children under five in developing countries, alternative scenarios

Variable	1995 mean (1)	Annual increase in variable, 1985–95 (2)	2020 scenarios: Status quo (3)	2020 scenarios: Pessimistic (4)	2020 scenarios: Optimistic (5)
Prevalence of child malnutrition (*CHMAL*) (percent)	31	. . .	18.4	21.8	15.1
Number of children malnourished (millions under age five)	167.1	. . .	140.3	154.8	127.6
Access to safe water (*SAFEW*) (percentage points)	70.2	0.96	94.3	88.3	100.0
Female secondary school enrollment (*FEMSED*) (percentage points)	46.6	1.60	86.7	76.7	96.7
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.047	0.00071	1.066	1.061	1.070
Per capita dietary energy supply (*DES*)	2,559	. . .	2,821	2,662	2,978

Notes: The estimates for *SAFEW, FEMSED,* and *LFEXPRAT* are based on 1985–95 average annual growth rates (column 2) calculated from the reported values of the respective variables given in columns (4) and (6) of Table 16. In the status quo scenario, the rates are assumed to remain the same for the period 1995–2020. In the pessimistic scenario they are assumed to fall by 25 percent. In the optimistic scenario they are assumed to increase by 25 percent. When a variable hits its maximum, the estimated value for 2020 is replaced by the maximum. This is the case for the value given for *SAFEW* in the optimistic scenario. The estimates for *DES* are based on IFPRI IMPACT model projections as reported in Rosegrant et al. 1995. The projections correspond to future developments in food prices, agricultural productivity, research investments, population growth, and growth in nonagricultural incomes.

Three Scenarios

In the *status quo scenario,* safe water access, female secondary school enrollments, and the female-to-male life expectancy ratio improve at the same rates they improved over 1985–95 (Table 17, column 2). At these rates, 94.3 percent of the developing-country population would have access to safe water by the year 2020. The female secondary school enrollment rate would increase from 47 percent to 87 percent by 2020. The female-to-male life expectancy ratio would rise to 1.066. Per capita dietary energy supplies would rise from 2,595 to 2,821 kilocalories corresponding to current trends in agricultural research investments, population growth, and non-agricultural income growth.

Under the *pessimistic scenario,* the rate of improvement in the nonfood underlying-determinant variables is assumed to decline by 25 percent. Under this circumstance, access to safe water rises to only 88.3 percent, the female secondary school enrollment rates rises to 77 percent, and the female-to-male life expectancy ratio to 1.061. Per capita dietary energy supplies are assumed to rise to 2,662 kilocalories. This latter projection is based on the IMPACT model's "low-investment/slow growth" scenario, in which international donors eliminate public investment in national agricultural research systems and extension services in developing countries and phase out direct core funding of international agricultural research centers. In addition, nonagricultural income growth is reduced by 25 percent from 1990 levels.

In the *optimistic scenario*, the rate of improvement in safe water access is enhanced by 25 percent, leading to universal access by the year 2020. The female secondary school enrollment rate climbs to more than double the 1995 prevalence, reaching 97 percent. The female-to-male life expectancy ratio rises to 1.07. Corresponding to annual increases of US $750 million in funding for national and international agricultural research and a 25 percent increase in nonagricultural income growth, per capita dietary energy supplies increase to 2,978 kilocalories (the "high investment/rapid growth" scenario of the IMPACT model).

The base predicting equation for the 2020 projections is:

$$\Delta C\hat{M} = C\hat{M}_{2020} - C\hat{M}_{1995} = -.076\,\Delta SAFEW - .220\,\Delta FEMSED$$
$$-71.8\,\Delta LFEXPRAT - .017\,\Delta DES1 - .002\,\Delta DES2 + 0.0\,\Delta DES3. \qquad (22)$$

The projections are undertaken using both full-sample and regional predictions of the underlying-determinant explanatory variables rather than predictions for each country individually. The 2020 prevalence is recovered from $\Delta C\hat{M}$ as

$$C\hat{M}_{2020} = \Delta C\hat{M} + CM_{1995}. \qquad (23)$$

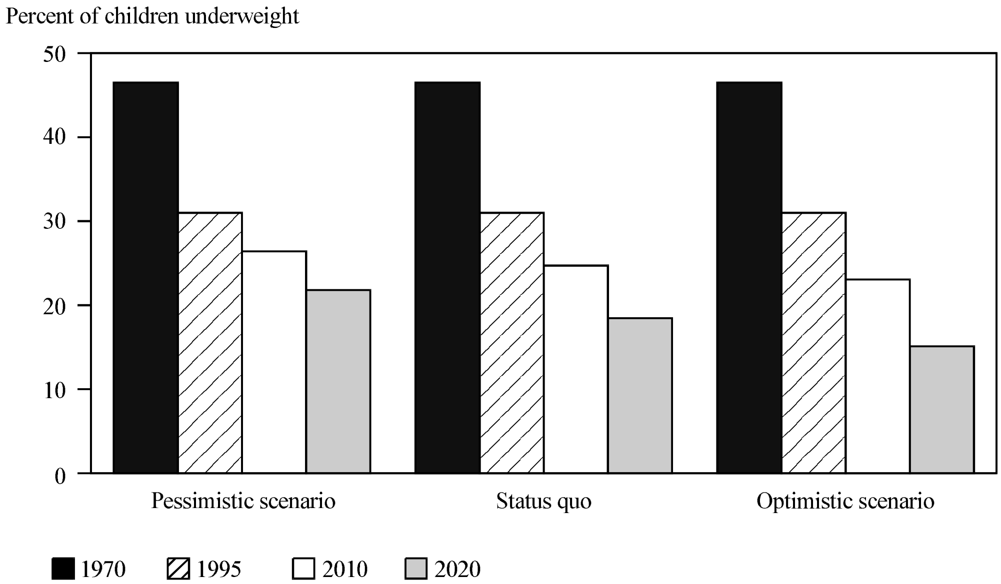
Table 18, rows (1) and (2) report the resulting projections of the prevalences and numbers of malnourished children in 2020. Figure 21 maps out the projections under each scenario for 1970, 1995, 2010, and 2020, showing their expected evolution over

Table 18—Projections to 2020 of the prevalence and numbers of malnourished children in developing countries, alternative scenarios, by region

	Percent underweight				Number underweight			
Region	**1995**	**2020 status quo**	**2020 pessimistic**	**2020 optimistic**	**1995**	**2020 status quo**	**2020 pessimistic**	**2020 optimistic**
		(percent under age five)				(millions under age five)		
South Asia	49.3	37.4	40.3	34.5	86.0	66.0	71.1	60.9
Sub-Saharan Africa	31.1	28.8	32.4	25.7	31.4	48.7	54.6	43.3
East Asia	22.9	12.8	13.1	12.6	38.2	21.4	21.9	20.9
Near East and North Africa	14.6	5.0	7.4	3.7	6.3	3.2	4.8	2.4
Latin America and the Caribbean	9.5	1.9	4.0	0.0	5.2	1.1	2.3	0.0
All developing countries	31.0	18.4	21.8	15.1	167.1	140.3	154.6	127.6

Notes: The estimates are based on projected future values of the underlying-determinant explanatory variables reported in Table 17.

Figure 21—Evolution of child malnutrition prevalence, all developing countries, 1970–2020



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

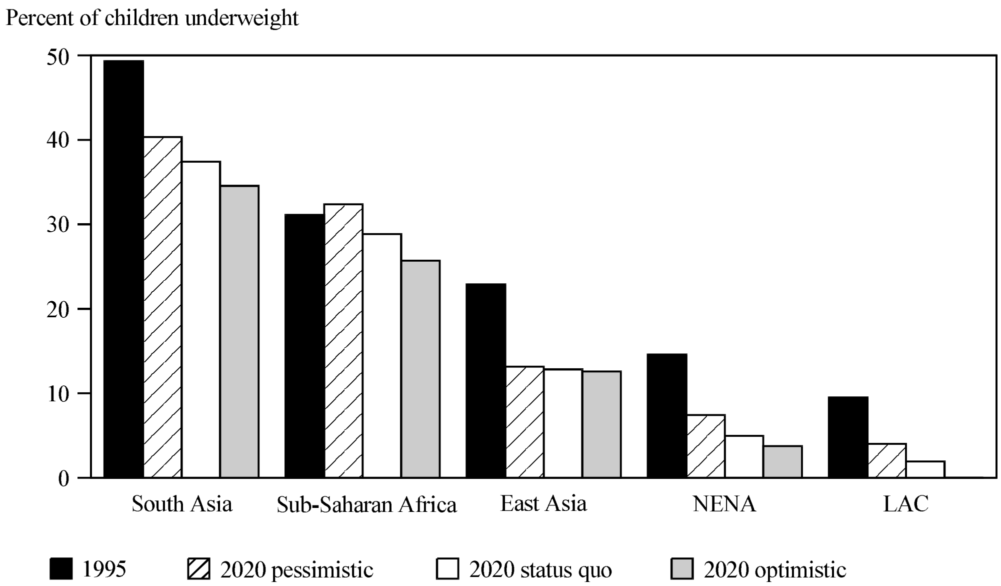
the 50-year period. Under the pessimistic scenario, the percent of developing-country children expected to be malnourished in 2020 would fall to 21.8. The numbers would fall from a 1995 level of 167.1 million to 155 million, a reduction of only 12.3 million children. The status quo scenario is projected to lead to a 12.6 percentage point reduction in the prevalence (which is close to the reduction over the 25 years from 1970 to 1995). The numbers of children malnourished would decrease by 26.8 million. Under the optimistic scenario of more rapid improvement in the determinants, the child malnutrition prevalence would remain fairly high, but fall to 15.1 percent. Even under this most positive of scenarios, 128 million children would remain malnourished, a reduction of only 39.5 million children from present levels.

Regional Projections

The projections for the developing countries as a whole mask wide variation across the regions. The regional projections in Table 18 are illustrated in Figures 22 (for prevalence) and 23 (for numbers). There are several points to note.

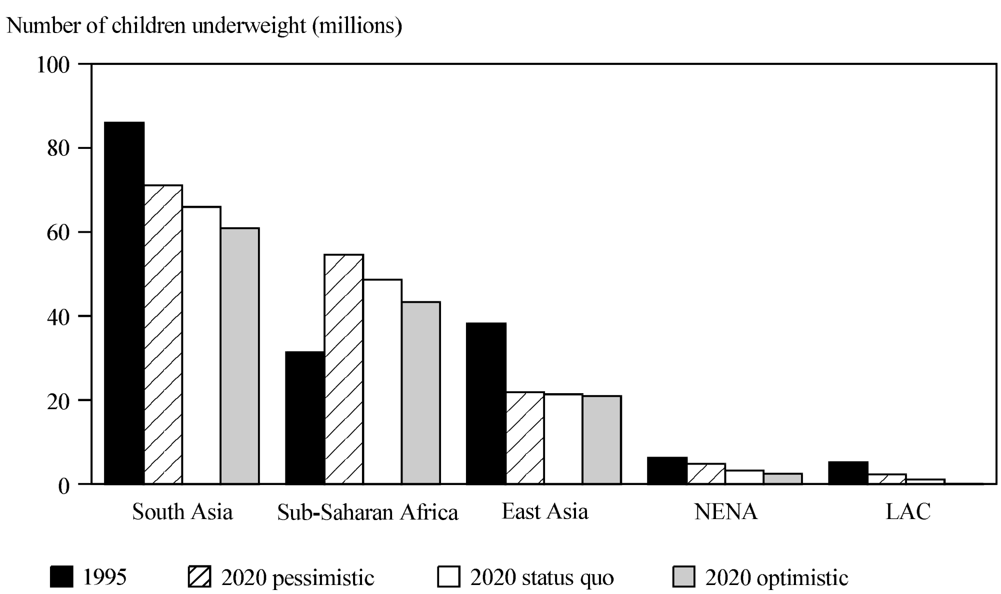
- Under all scenarios **South Asia** will remain the region with the highest prevalence and numbers of malnourished children. However, both will fall rapidly

Figure 22—Projections of child malnutrition prevalence to 2020, by region



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

Figure 23—Projections of number of malnourished children to 2020, by region



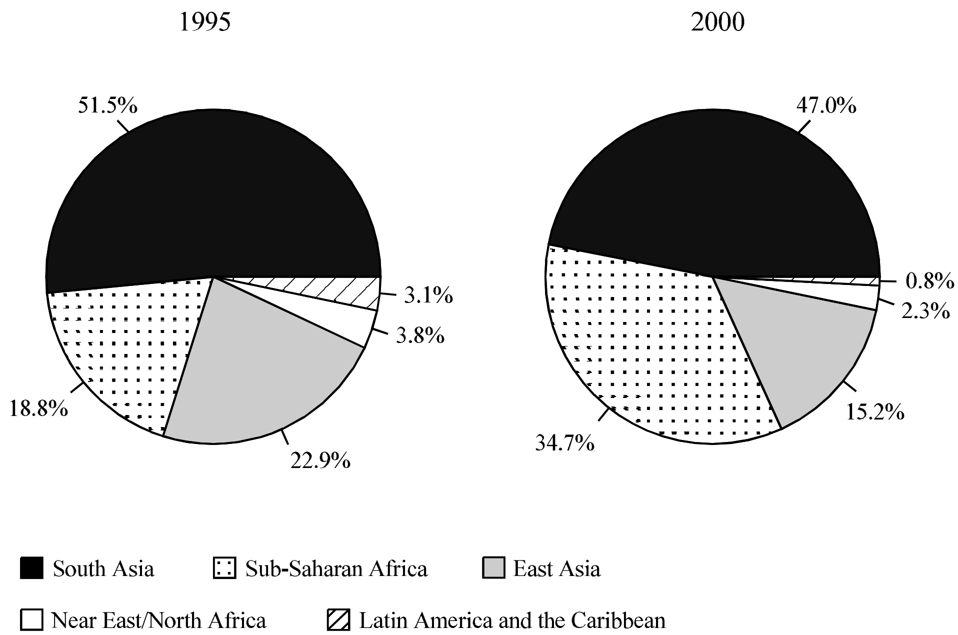
Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

over the 1995–2020 period. In the status quo or most likely scenario the prevalence will fall from 49.3 percent to 37.4 percent. Despite a slight increase in the population of children under five (from 174 to 176 million), the numbers of malnourished children will fall from 86 million to 66 million, a 23 percent decline.

- Little progress in reducing child malnutrition will be made in **Sub-Saharan Africa**. Under the pessimistic scenario, the prevalence is predicted to *increase,* from a 1995 rate of 31.1 percent to 32.4 percent in 2020. Even under the optimistic scenario the prevalence would drop only by 5.4 percentage points. Given slow rates of decrease in the prevalence and very large expected increases in the numbers of children under five (101 to 169 million), under all scenarios the numbers of children are expected to increase in the region. They rise to as high as 55 million under the pessimistic scenario, a number not far below those for South Asia.
- The prevalence and numbers of malnourished children are expected to decline the fastest in the **East Asia** region. Under all scenarios the prevalence is nearly cut in half, falling to about 12 percent of the population. No increase is expected in the number of children under five. The numbers of malnourished children thus fall precipitously from 38.2 to around 21 million.
- In the **Near East and North Africa** region malnutrition will fall to very low levels, except under the pessimistic scenario, in which almost 5 million children under five will remain malnourished.
- Malnutrition will practically be eliminated in **Latin America and the Caribbean** (although there will likely remain some countries within the region for which rates remain high).

Corresponding to these predicted trends, the regional configuration of the locations of malnourished children in the developing world is expected to change considerably by the year 2020 (Figure 24). Under the status quo scenario South Asia's share is predicted to remain high, but to fall from 51 percent to 47 percent. Sub-Saharan Africa's is expected to rise from 19 percent in 1995 to almost 35 percent by the year 2020.

Figure 24—Regional distribution of underweight children, 1995 and 2020



Source: IFPRI Cross-Country Child Malnutrition Determinants Data Set, 1997/98.

CHAPTER 8

Priorities for the Future

Chapter 6 of this report examined the past record of reductions in child malnutrition and attempted to isolate the contributions of four variables representing its underlying determinants and two variables representing its basic determinants. Chapter 7 then developed three scenarios for child malnutrition in the year 2020 based on past trends in the underlying-determinant variables. The scenarios are essentially the answer to the question “If we continue as in the past (or continue doing a little more or a little less), what will the future look like?” Even under the most optimistic of the scenarios, the developing-country prevalence of child malnutrition is expected to be 15 percent in 2020: 128 million children would still be malnourished. But the future doesn’t have to look like the past.

This chapter asks: “What combinations of actions would lead to the greatest reductions in child malnutrition in the developing countries by 2020, and how difficult would they be to put into effect?” In answering this question it is important to keep three things in mind. First, as the conceptual framework of this paper lays out and the analysis has confirmed, all three underlying determinants—food security, mother and child care, and a healthy environment—are necessary for a child to achieve adequate nutritional status. Thus, strategies for reducing child malnutrition should include actions to address all of them. The issue considered here is the *relative* emphasis that should be placed on the various contributing factors.

Second, factors associated with both underlying and basic determinants were found to have strong effects on child malnutrition, with the former being dependent on the latter. The question is not which set of determinants should be prioritized: *both* underlying and basic determinants should be the focus of future efforts to reduce child malnutrition.

Finally, actions associated with the determinants considered in this report should be seen as supporting crucial direct nutrition interventions, such as community-based programs to improve home-based caring practices, micronutrient supplementation, and food fortification (see Gillespie, Mason, and Martorell 1996). In addition, the reader should keep in mind that strategies for increasing per capita dietary energy supplies and per capita national incomes can include not only raising food supplies and national incomes but also reducing population growth.

The Relative Importance of the Underlying-Determinant Variables to Future Reductions in Child Malnutrition

The analysis of Chapter 5 showed that the strength of the effect of national food availability on child malnutrition for any population depends strongly on the level currently reached. The *relative* strengths of the underlying-determinant variables thus also depend on current food availability. Using the estimates of Table 7, column (3), Table 19 classifies the developing countries into three food availability groups, a "high impact" group, whose per capita DESs are below 2,300 kilocalories, a "medium impact" group, whose per capita DESs are between 2,300 and 3,120; and a "low impact" group, with per capita DESs above 3,120 kilocalories. Most of the countries in South Asia and Sub-Saharan Africa fall into the high impact group. Some, however, among which are countries with very high prevalences of child malnutrition such as India, Mauritania, Nigeria, and Pakistan, fall into the medium impact group. Most countries in East Asia and LAC fall into the medium impact group. However, some countries in these regions with very low per capita DESs—Bolivia, Cambodia, Guatemala, Haiti, Laos, Mongolia, and Peru—fall into the high impact group. Barbados, the Republic of Korea, and Mexico, as well as a large number of NENA countries, fall into the low impact group, in which further increases in food availabilities are unlikely to lead to improvements in children's nutritional status.

The country classification given in Table 19 helps to compare the strengths and potential impacts of the underlying-determinant variables for each developing region. The upper panel of Table 20 gives the comparison. In column (2), calculations of the absolute increase in each variable's proxy measure needed to bring about a reduction in the child malnutrition rate of 1 percentage point by region in 1995 are presented. For example, in South Asia an increase in the rate of access to safe water (representing the health environment) of 13.1 percentage points would have the same effect on child malnutrition rates as would an increase in per capita DES of 94 kilocalories. But, as discussed earlier, the different units in which the variables are measured make this column difficult to interpret. Therefore, the absolute increases are standardized by the range of the variables observed in developing countries to gauge how realistic they are (column 3).

In South Asia and Sub-Saharan Africa, food availability emerges as the factor that needs to change the least—relative to its existing range—to bring about a 1 percentage-point drop in child malnutrition rates. It is thus the most potent force in reducing child malnutrition in these regions. Following closely is women's education (measured as female secondary school enrollment rates) in both regions. In the remaining three regions, women's education is by far the most potent force for reducing child malnutrition. In all regions except NENA, health environment is the factor that needs to change the most, relative to its range, to bring about a 1 percentage-point reduction in child malnutrition.

While the numbers in column (3) provide a sense of how large a change is required in each underlying-determinant variable to bring about the same reduction in child malnutrition, they say nothing about the distance of the variables from their

Table 19—Strength of impact on child malnutrition of national food availability, by high, medium, and low impact

Region	High impact (DES less than 2,300)[a]	Medium impact (DES between 2,300 and 3,120)	Low impact (DES greater than 3,120)
South Asia	Afghanistan, Bangladesh, Nepal, Sri Lanka	India, Maldives, Pakistan	
Sub-Saharan Africa	Angola; Botswana; Burkina Faso; Burundi; Cameroon; Central African Republic; Chad; Comoros; Congo, Democratic Republic of; Congo, Republic of; Djibouti; Eritrea; Ethiopia; Gambia; Guinea; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mozambique; Namibia; Niger; Rwanda; Sao-Tome and Principe; Sierra Leone; Somalia; Tanzania; Togo; Uganda; Zambia; Zimbabwe	Benin, Côte d'Ivoire, Gabon, Ghana, Guinea-Bissau, Mauritania, Mauritius, Nigeria, Senegal, Sudan, Swaziland	
East Asia	Cambodia, Laos, Mongolia	Brunei; China; Indonesia; Korea, Democratic People's Republic of; Macau; Malaysia; Myanmar; Philippines; Thailand; Viet Nam	Korea, Republic of
Near East and North Africa	Iraq, Yemen	Algeria, Iran, Jordan, Kuwait, Saudi Arabia, Tunisia	Cyprus, Egypt, Lebanon, Libya, Morocco, Syria, Turkey, United Arab Emirates
Latin America and the Caribbean	Bolivia, Guatemala, Haiti, Peru	Argentina, Bahamas, Belize, Brazil, Chili, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Guyana, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Suriname, Trinidad and Tobago, Uruguay, Venezuela	Barbados, Mexico

Notes: The country classifications are based on cut-offs determined by the two knots of a three-segment linear spline function for DES in a regression on underweight prevalence (see Table 7, column 3). The DESs are for 1995 as reported in FAO 1998.

[a] DES = Per capita dietary energy supply measured in kilocalories.

Table 20—Comparison of the strengths and potential impacts of factors affecting child malnutrition, 1995

Region/variable	1995 mean (1)	Increase in variable needed to reduce prevalence of child malnutrition by 1 percentage point (2)	Number in (2) as a percent of developing-country range[a] (3)	Percent determinant is below its desirable level[b] (0–100 scale) (4)	Change in prevalence of child malnutrition with increase in determinant to desirable level[c] (5)
			(percent)	(percent)	(percentage points)
Underlying-determinant variables					
South Asia					
Access to safe water (*SAFEW*)	79.7	13.1	13.2	–20.3	–1.6
Female secondary school enrollment (*FEMSED*)	34.1	4.6	4.6	–65.9	–14.5
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.023	0.0139	9.3	–58.9	–5.5
Per capita dietary energy supply (*DES*)	2,356	94	4.5	–46.5	–3.0
Sub-Saharan Africa					
Access to safe water (*SAFEW*)	48.8	13.1	13.2	–51.2	–3.9
Female secondary school enrollment (*FEMSED*)	19	4.6	4.6	–81.0	–17.8
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.054	0.0139	9.3	–35.2	–3.3
Per capita dietary energy supply (*DES*)	2,136	75	3.6	–60.2	–5.2
East Asia					
Access to safe water (*SAFEW*)	66.5	13.1	13.2	–33.5	–2.6
Female secondary school enrollment (*FEMSED*)	59.8	4.6	4.6	–40.2	–8.8
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.0514	0.0139	9.3	–37.4	–3.5
Per capita dietary energy supply (*DES*)	2,720	188	9.0	–23.8	–2.1
Near East and North Africa					
Access to safe water (*SAFEW*)	81.5	13.1	13.2	–18.5	–1.4
Female secondary school enrollment (*FEMSED*)	57.9	4.6	4.6	–42.1	–9.2
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.044	0.0139	9.3	–42.8	–4.0
Per capita dietary energy supply (*DES*)	3,172	333	16	+4.5	–0.2

(continued)

Table 20—Continued

Region/variable	1995 mean (1)	Increase in variable needed to reduce prevalence of child malnutrition by 1 percentage point (2)	Number in (2) as a percent of developing-country range[a] (3)	Percent determinant is below its desirable level[b] (0–100 scale) (4)	Change in prevalence of child malnutrition with increase in determinant to desirable level[c] (5)
			(percent)	(percent)	(percentage points)
Latin America and the Caribbean					
Access to safe water (*SAFEW*)	77.3	13.1	13.2	–22.7	–1.7
Female secondary school enrollment (*FEMSED*)	56.5	4.6	4.6	–43.5	–9.6
Female-to-male life expectancy ratio (*LFEXPRAT*)	1.098	0.0139	9.3	–1.9	–0.18
Per capita dietary energy supply (*DES*)	2,777	234	11.2	–20.2	–1.8
Basic-determinant variables[d]					
Per capita GDP (*GDP*)	2,121	202	9.7	–59.1	–18.5
Democracy (*DEMOC*)	2.71	0.79	11.5	–71.5	–5.5

Note: The table compares the relative strengths of the underlying-determinant variables to one another and those of the basic-determinant variables to one another. Since the two groups lie at different levels of causality, it is important not to compare the results for variables *across* the groups.

[a] See Table 12 for variable ranges.

[b] The desirable levels of the variables are: *SAFEW*: 100 percent; *FEMSED*: 100 percent; *LFEXPRAT*: 1.1 (this is the average of the highest 20 percent of country-year data points in the sample in terms of female-to-male life expectancy ratios [excluding the highest, which is 1.15 and far above the next highest, 1.12]); *DES*: 3,100 (see text footnote for rationale); *GDP*: The desirable level is set at $4,750. This is the level past which improvements in *GDP* per capita no longer contribute to reductions in child malnutrition; *DEMOC*: 7 (the maximum value of the index).

c These numbers are calculated using the regression coefficients in Table 8 columns (3) and (4). For *DES* and *GDP*, each region's number is calculated using country averages.

[d] Because the structural relationship between *CHMAL* and basic determinants differs by regions, reliable regional breakdowns cannot be provided.

desirable levels and hence the scope for reducing child malnutrition over the medium to long run. The percent that each variable's proxy measure is below its desirable level (in scale-neutral terms) is given in column (4). The desired levels of safe water access and female secondary school enrollment rates are assumed to be 100 percent. The desired level of the female-to-male life expectancy ratio is set at 1.1; that of per capita DES is set at 3,100.[45]

Table 20, column (5) gives the estimated reduction in the child malnutrition prevalence if each variable were raised to its desirable level. The results imply that in all regions, increasing women's education to desirable levels has the largest medium-term to long-term potential to reduce child malnutrition. Food availability is second in Sub-Saharan Africa and LAC. Women's relative status is second in South Asia, East Asia, and NENA.

To identify policy priorities for future reductions in child malnutrition for each region, the four underlying-determinant variables are ranked in terms of the size of (1) the change required to bring about a 1 percentage-point reduction in child malnutrition as a percentage of the determinants' ranges (based on Table 20, column 3), and (2) their scope for reducing child malnutrition prevalences in the medium-to-long term (based on column 5). Future policy priorities for addressing the underlying determinants of child malnutrition in each developing region are arrived at by combining these two ranks. They are summarized in Table 21.

In South Asia and Sub-Saharan Africa the top priorities are food availability and women's education. In both regions, food availability improvements have the strongest effect, but women's education has a strong effect *and* would make the biggest difference if increased to a desirable level. In East Asia, NENA, and LAC, women's education is the top priority, both from the standpoint of strength of impact and scope for reducing child malnutrition. For South Asia, a secondary priority is improving women's status relative to men's, which, because it is so far below desirable levels, has great scope for reducing malnutrition. In East Asia, food availability and women's relative status should also be prioritized. In NENA, women's relative status is a secondary priority. In LAC, women's relative status and health environment improvements tie for second priority.

Health environment improvements, in a *relative* sense, appear to be a weak force for reducing child malnutrition. The low ranking is partially because there has already been substantial progress made in this area compared to the others (Table 20, column 4). In an absolute sense, health environment improvements still make quite a

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[45] The desired level of the female-to-male life expectancy ratio is determined as the average of the top 20 percent of the data points in the panel data set, excluding the maximum value (1.15) of El Salvador in 1988, which is an extreme value compared to the other high ratios. There is no widely accepted "desirable" level of per capita DES from the standpoint of nutritional health. Countries with very high levels also have high levels of obesity, an undesirable trait. For example, in 1995, countries of Western Europe had an average DES of 3,360 (FAO 1998). Near a DES of 3,120 kilocalories, increases in DES no longer serve to reduce child malnutrition levels. Alexandratos (1995) cites the general case that 10 percent of a country's population will be undernourished (or food insecure) at DES levels of 2,700 kilocalories. On the other hand, FAO (1996) claims that at a level of about 2,770 only 2.5 percent of the population will be undernourished. An intermediate level of 3,100 kilocalories is chosen here.

Table 21—Priorities by region for future child malnutrition reduction (underlying-determinant variables)

Region	Rank of determinants by most potent impact on malnutrition relative to its existing range (1)	Rank of determinants by most potential for impact based on increases to desirable levels (2)	Top priorities (3)
South Asia	1. Food availability 2. Women's education 3. Women's relative status 4. Health environment	1. Women's education 2. Women's relative status 3. Food availability 4. Health environment	1. Food availability 1. Women's education 2. Women's relative status
Sub-Saharan Africa	1. Food availability 2. Women's education 3. Women's relative status 4. Health environment	1. Women's education 2. Food availability 3. Health environment 4. Women's relative status	1. Food availability 1. Women's education
East Asia	1. Women's education 2. Food availability 3. Women's relative status 4. Health environment	1. Women's education 2. Women's relative status 3. Health environment 4. Food availability	1. Women's education 2. Food availability 2. Women's relative status
Near East and North Africa	1. Women's education 2. Women's relative status 3. Health environment 4. Food availability	1. Women's education 2. Women's relative status 3. Health environment 4. Food availability	1. Women's education 2. Women's relative status
Latin America and the Caribbean	1. Women's education 2. Women's relative status 3. Food availability 4. Health environment	1. Women's education 2. Health environment 3. Food availability 4. Women's relative status	1. Women's education 2. Women's relative status 2. Health environment

Notes: The rankings in column (1) are based on the numbers reported in Table 20, column (3). The rankings in column (2) are based on the numbers reported in Table 20, column (5). The top priorities in column (3) are based on the highest ranked determinants in columns (1) and (2).

big difference, however. If universal access to a proper health environment (proxied by safe water) were achieved, the prevalence of child malnutrition is estimated to fall by 2.3 percentage points. The numbers of malnourished children would fall by 11.9 million. The potential of health environment improvements for reducing child malnutrition is the greatest in Sub-Saharan Africa.

On a final note, the independent effect of poverty on child malnutrition has not been assessed due to lack of sufficient data. Most certainly a large proportion of the effect of food availability is from increased real incomes, whether in the form of increased production of food consumed directly by households, increased cash incomes to purchase food and other nutrition inputs, or reduced food prices. Proactive efforts to improve food availability through means that simultaneously increase the incomes of the poor are likely to result in greater nutrition benefits than efforts focused solely on raising food supplies (see Smith et al. 1999).

The Relative Importance of National Income and Democracy

As this report has shown, democracy is important in facilitating health environment improvements and increases in food availability. Per capita national income is important in maintaining and improving investments in health environment improvements, women's education, women's relative status, and food availability both from the viewpoint of public investments and (through its association with household incomes) investments at the household level. Strong regional differences in the effects of the two basic-determinant variables have been detected. However, because the regional differences could not be detected (see Chapter 5), this discussion of the relative importance of the two variables is limited to their importance for the developing countries as a group.

At this point in history it appears that raising national incomes would have a stronger effect on child malnutrition than enhancing democracy. An increase in the developing country per capita GDP of $202 is needed to reduce the child malnutrition prevalence by 1 percentage point, which is 9.7 percent of its range (Table 20, lower panel). By contrast, it would take almost a 0.8 point rise in the democracy index to bring about the same reduction, which is 11.5 percent of its range. The developing-world per capita GDP is currently far below any desirable number. Past a level of about $4,750 the factor loses its force in reducing child malnutrition. Even bringing the developing-country GDP up to this moderate level would have quite a large impact on child malnutrition: the prevalence would fall by a predicted 18.5 percentage points, the numbers by almost 100 million. The regions that have the longest way to go to reach the $4,750 mark (and thus the most to gain from doing so) are Sub-Saharan Africa, South Asia, and East Asia. LAC as a region has already surpassed the mark (Appendix Tables 25–29).

While, relatively speaking, democracy is not a very strong force in reducing child malnutrition in the developing countries, in an absolute sense, improving it would make a big difference. If the democracy index were raised to its desired level (of 7), it is estimated that the prevalence of child malnutrition in the developing countries would fall by 5.5 percentage points. The numbers of children who are malnourished would be reduced by 29.4 million. The regions that have the longest way to go to reach a desirable level of democracy are East Asia, NENA, and Sub-Saharan Africa (Tables 25–29).

The reader should bear in mind that improvements in national income and democracy only lead to reductions in child malnutrition *if* they are directed to improvements in the underlying determinants. Given enhanced political will and education, it is possible that they can be even more effectively directed toward them in the future than they have in the past. This analysis gives governments an idea of where to best direct increased national incomes in the interests of children's nutrition. It also suggests target areas in which political will and commitment among democratic governments can be instilled.

A Note on Cost-Effectiveness

On a final note, a full assessment of priorities for the future should ideally take into account the costs of improving the alternative factors. While the same reduction in child malnutrition could be brought about by a 13.1 percentage-point increase in access to safe water as a 4.6 percentage-point increase in the female secondary school enrollment rate, it is unlikely that these increases would cost the same. Costs are likely to differ by region as well. Unfortunately, good-quality comparative information on cost-effectiveness of alternative investments is lacking. One can still get a sense of how different the relative costs have to be before the conclusions reached on priorities are altered. For example, if it cost more than 2.8 times to increase female secondary school enrollment by 1 percent compared with increasing access to safe water by 1 percent, then the latter will be the more cost-effective investment in reducing malnutrition. If the ratio is below 2.8, then female secondary school education becomes more cost-effective. Better information on cost-effectiveness should be the focus of future research on policies to improve child nutritional status.

Box 2

The (South) Asian Enigma

In South Asia, 50 percent of the children under age five are malnourished; in Sub-Saharan Africa, 31 percent. Why is malnutrition so much higher in South Asia? The huge difference has been called an "enigma" because South Asia as a region is doing much better than Sub-Saharan Africa for most of the determinants of child malnutrition (see the table below) (Ramalingaswami, Johnsson, and Rohde 1996). There are three possible sources of these differences.

First, the determinants of child malnutrition may be different or have different strengths of impact in the regions. If one determinant is more important in South Asia than in Sub-Saharan Africa, and South Asia is not doing well in that area, then that determinant could be a clue to the enigma. This report finds no major differences in the importance of the underlying-determinant causal factors between the regions. For the basic determinants, some structural differences were evident, but it was not possible to find out which determinant, national income or democracy, was causing the difference.

The second possible source of the difference in child malnutrition rates may be that South Asia is doing worse than Sub-Saharan Africa in the factors studied. As the table shows, South Asia is doing better than Sub-Saharan Africa for all factors except women's status relative to men's. Therefore, it seems likely that women's status is one reason for the higher prevalence of malnutrition in South Asia. The table

Progress in some determinants of child malnutrition in South Asia and Sub-Saharan Africa, 1995

	South Asia	Sub-Saharan Africa
Child malnutrition (percent)	49.3	31.1
Access to safe water (percent)	79.7	48.8
Female secondary school enrollment (percent)	34.2	19
Female-to-male life expectancy ratio	1.023	1.054
Per capita dietary energy supply (kilocalories)	2,356	2,136
Per capita national income (PPP US$)	1,136	778
Democracy	4.10	2.44
Poverty (percent)[a]	43.1	39.1

Sources: Tables 1, 25, and 26. Poverty data are from Ravallion and Chen 1996, Table 5.

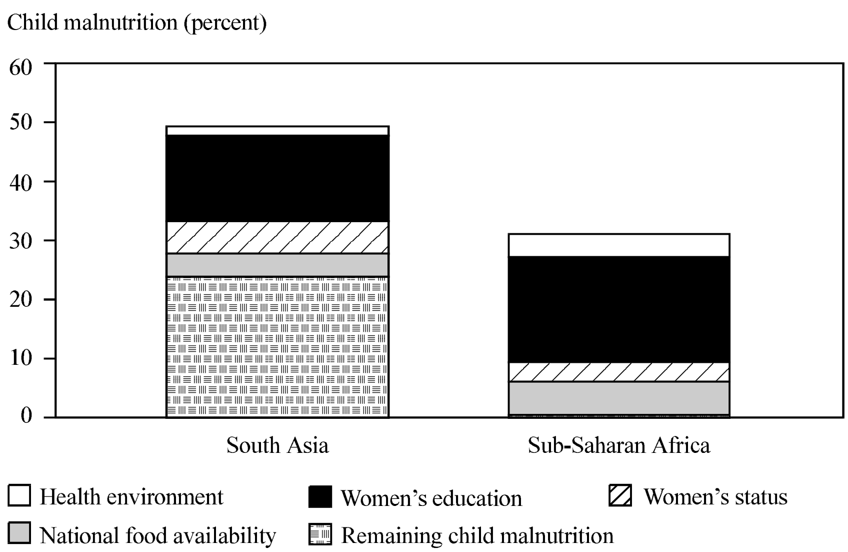
Notes: With the exception of the poverty rates, these data are population-weighted means over all countries in the data set in each region. The poverty measure employs an international poverty line of $1 per person per day at 1985 purchasing power parity.

[a] Poverty figures are for 1993.

also indicates that South Asia's poverty rate is slightly higher than Sub-Saharan Africa's, which may explain some of the difference.

The final source of the difference in child malnutrition rates of the two regions lies in the "black box" of time-invariant, country-specific factors. Because the data set covers more than one point in time for each country, the effects on child malnutrition of these factors can be estimated, even though it is not possible to determine what they actually are. The factors are found to raise the prevalence of child malnutrition in South Asia well above Sub-Saharan Africa's. To illustrate their importance in the regional differences, the figure below shows how much child malnutrition would remain, even if all of the underlying-determinant variables were raised to their desirable levels. In South Asia, malnutrition would remain at 23.8 percent, but it would be only 0.5 percent in Sub-Saharan Africa. Deeply entrenched factors specific to South Asian countries, then, are also key to solving the Asian enigma. In the long run, if child malnutrition is to be overcome in the region, the black box must be opened to find out what these factors are and to implement policies to address them. Some possibilities are the monsoon climate (FAO 1996), recurrent flooding in some countries, overcrowding due to high population density, and cultural beliefs and traditions that hinder optimal breast feeding and timing of the introduction of complementary foods (Ramalingaswami, Jonsson, and Rohde 1996).

Predicted reductions in child malnutrition and remaining prevalence if underlying-determinant variables reach desirable levels



Source: IFPRI Cross-Country Child Malnutrition Data Set, 1997/98.

CHAPTER 9

Conclusions

Thirty percent—167 million—of all developing-country children under five are currently underweight. This study uses historical cross-country data to improve understanding of the relative importance of the various causes of malnutrition for the developing countries as a whole and by region. In this way, it attempts to contribute to the debate on how to make the best use of available resources to reduce child malnutrition in developing countries now and in the coming years to 2020. It is hoped that the study will help policymakers who are committed to reducing child malnutrition prioritize their resource investments in order to reduce and eventually eliminate child malnutrition in the developing countries.

The conclusions of the report are based on estimations undertaken with careful consideration to data quality and statistical soundness. The research is guided by a well-accepted, comprehensive conceptual framework. It employs household survey-based, nationally representative data on child underweight prevalences that have been subjected to strict quality-control standards. It employs an estimation methodology—fixed-effects panel regression—that accounts for unobserved heterogeneity across countries, thus reducing bias in parameter estimates. Specification tests indicate that the models estimated are a reasonably good representation of the quantitative relationships between child malnutrition and the determinants considered.

Research Findings

This report has found strong evidence that the quality of countries' health environments, women's education, women's status relative to men's, and national food availability are important determinants of child malnutrition throughout the developing world. Termed "underlying-determinant variables," these factors were found to have statistically significant and quantitatively strong impacts on the prevalence of underweight children for a sample of 63 countries, representing 88 percent of the developing world population. The report also confirms that per capita national incomes and democracy, termed "basic-determinant variables," are also important factors. Lying at a deeper level of causality, these factors affect malnutrition mainly through facilitating investment in the underlying-determinant variables.

Past Progress: How Was It Achieved?

The regression results are used to estimate the contribution each factor made to the 15.5 percentage-point reduction in the prevalence of child malnutrition from 1970 to 1995. Among the underlying-determinant variables, increases in women's education contributed the most, accounting for 43 percent of the total reduction. Improvements in national food availability contributed 26 percent of the reduction, health environment improvements 19 percent. Because there was little improvement in women's relative status, its contribution—while still substantial—was the lowest (12 percent).

In South Asia, in addition to women's education, improvements in women's relative status and health environments made particularly large contributions. While South Asian countries' national food availabilities deteriorated during the world food crisis of the early 1970s, improvements in the 1980s made a large contribution. In Sub-Saharan Africa, child malnutrition has largely been reduced through improvements in health environments and increases in women's education. National food availability made very little contribution overall, although its positive impact on child nutrition in the last 10 years has demonstrated its potential. Declines in women's status relative to men's in the region have muted the positive impacts of the other determinants. In East Asia and the Near East and North Africa (NENA), increases in women's education and national food availability have made the greatest contributions. In Latin America and the Caribbean (LAC), women's education has been a major contributor throughout the 25 years; the other underlying-determinant variables have contributed relatively little.

In terms of the basic-determinant variables, improvements in per capita national income have made a substantial contribution, an estimated 7.4 percentage-point reduction in the developing-country prevalence of child malnutrition. The contribution was positive for all regions except Sub-Saharan Africa, where per capita national income declined during 1970–95. While democracy has a potentially large contribution to make, it made no contribution because no progress was made in this area for the developing countries as a whole during the period. Deteriorations in democracy have had a negative impact on child nutrition in South Asia and East Asia. Democracy's contribution has been positive for Sub-Saharan Africa, NENA, and LAC.

Child Malnutrition in the Year 2020

The regression results are also used to project the prevalence and numbers of malnourished children to the year 2020 under three scenarios for growth in the four underlying-determinant variables. A status quo scenario assumes that the nonfood variables increase at the rate they did over the 1985–95 period, while a pessimistic scenario assumes a 25 percent cut in the rate of change and an optimistic scenario assumes a 25 percent increase. For national food availability, IFPRI IMPACT model projections for per capita dietary energy supply are employed.

Under the status quo scenario, 18 percent of developing-country children under five are projected to be malnourished in 2020. The prevalence rises to 22 percent under the pessimistic scenario and falls to 15 percent under the optimistic scenario. The payoffs to the optimistic scenario can best be realized in Sub-Saharan Africa and South Asia. What is particularly striking is that even under an optimistic scenario the absolute numbers of malnourished children in Sub-Saharan Africa are projected to be higher in 2020 than in 1995. Based on the status quo projections, a sharp regional shift in the location of child malnutrition is predicted: South Asia's share will fall from 51 percent in 1995 to 47 percent in 2020, but Sub-Saharan Africa's share will increase from 19 percent in 1995 to near 35 percent in 2020.

Priority Actions for the Future

An assessment of the relative effectiveness of the four underlying-determinant variables in terms of their potential for generating future reductions in child malnutrition is carried out. The assessment takes into account the relative strength of impact of each variable and its distance from the desirable level as of 1995, but not the relative cost of investing in it. It finds that improvements in national food availability and in women's education offer the best hope for future reductions in child malnutrition in Sub-Saharan Africa and South Asia. In South Asia, an additional priority is to improve women's status relative to men's. In East Asia, NENA, and LAC, the primary priority for reducing child malnutrition is improving women's education; the second highest priority is to improve women's relative status. Additional secondary priorities are national food availability for East Asia and health environment improvements for LAC. Policies for increasing national food availabilities should consider measures to reduce population growth as well as to increase food supplies, and should be formulated with the goal of improving food security.[46]

A key message of this report is that significant achievement can be made toward reducing malnutrition through actions in sectors that have not been the traditional focus of nutrition interventions. A second key message is that any comprehensive strategy for attacking the problem of child malnutrition must include actions to address both its underlying *and* basic causes. Without improvements in national incomes and democracy, the resources and political will to invest in the underlying-determinant factors—in health environments, women's education and status, and food availabilities—will not be there. If improved national incomes and democracy are not directed to improvements in the underlying-determinant factors, on the other hand, they will make little difference. Investments in all of the factors will support the crucial role of direct nutrition programs at the community level.

[46] Simply maintaining the determinants at their current levels will require substantial resources in many countries. This is particularly so for national per capita food availability, which has to be maintained in the face of increasing populations and a fairly fixed amount of cultivable land.

Contributions to the Resolution of Key Debates

This research contributes to the resolution of five important debates currently under way in development policy and research circles. First, why has child malnutrition been rising in Sub-Saharan Africa? The report finds that some of the increase is likely due to deteriorations in the status of women relative to men and per capita national incomes. Stagnation in national food availability and women's education have also held back improvements in child nutrition. Finally, debt and structural adjustment, increasing conflict levels, and the rise of HIV/AIDS may all play a part.

Second, why are child malnutrition rates in South Asia so much higher than in Sub-Saharan Africa? This study identifies a key variable as the source of the "Asian enigma": women's status relative to men's. Regardless of the levels of the factors influencing child malnutrition that are identified in this report, however, a large disparity in prevalences of child malnutrition would persist between the two regions. The source of this remaining difference is time-invariant factors specific to South Asian countries that the report has not been able to explicitly identify. Some possibilities might be the region's monsoon climate, high population densities, and deeply entrenched beliefs about child feeding practices.

Third, how important is food availability as a determinant of child malnutrition at the national level? The report finds that when it is very low (below a per capita DES of approximately 2,300 kilocalories), it is a particularly strong determinant. But, after a certain point is reached (at a per capita DES of approximately 3,120 kilocalories), further increases are unlikely to aid in reducing child malnutrition. For countries with such high food availabilities, efforts to promote food security must focus on promoting access to food at the household level. The regions in which improved food availability has the most to contribute in the coming decades are South Asia and Sub-Saharan Africa. Pro-active efforts to improve food availability through means that simultaneously increase the incomes of the poor (without compromising care of children) are likely to result in greater nutritional benefits than efforts focused solely on raising food supplies.

Fourth, how important are women's status and education? This research report confirms the now overwhelming evidence that women's education has a strong impact on children's nutrition. It also establishes that women's status relative to men's is an important determinant of child malnutrition in all developing-country regions. These findings confirm women's key role in the etiology of child nutrition, whether through the pathway of maternal and child care or household food security. Together, improvements in women's education and status alone were responsible for more than 50 percent of the reduction in child malnutrition that took place from 1970 to 1995. More emphasis should be placed on improving them in the future, especially on women's status and education in South Asia and on women's education in Sub-Saharan Africa.

Fifth, how important are national incomes and political factors such as democracy, and through what pathways do they affect child malnutrition? This report finds that national incomes have a very strong influence on child nutrition. Increases in per capita national income during 1970–95 contributed to almost half of the total reduction in the prevalence of child malnutrition in developing countries, working via all four underlying-determinant factors. The existence of a significant link between the degree of democracy in countries and the prevalence of child malnutrition has been firmly established, with democracy contributing mainly through improvements in health environments and national food availability. Why democracy is important for these two factors and not for others needs to be better understood. Nevertheless, the analysis suggests that political variables have as valid a place in studies of malnutrition as they do in studies of economic growth.

Limitations of the Study

This research does not adequately consider two factors believed to have a strong influence on child malnutrition: food security at the household level and poverty. At present no cross-country comparable data are available on national rates of food insecurity from household survey data (Smith 1998a). Instead, data on per capita dietary energy supplies are used; these are an inadequate measure of food insecurity because they do not measure food access. While some cross-country data on poverty exist (World Bank 1998b), at present data are not adequate to reliably estimate this variable's influence on child malnutrition.

The second limitation of this study is its inability to address the sequential nature of optimal interventions for improving child nutritional status. In many cases one intervention, for example provisioning of health services, needs to be undertaken before others have any positive impact. The estimation methodology used here only permits estimating each explanatory variable's impact as if interventions were to take place simultaneously.

A third limitation of the study is that the costs of various interventions cannot be taken into consideration in setting policy priorities. But, from a practical standpoint, cost-effectiveness must play a crucial role in any decision about what kinds of policies and programs to put in place for reducing child malnutrition as quickly and efficiently as possible.

Directions for Future Research

This report points to a number of fruitful directions for future research. These include (1) a similar analysis for rates of stunting, which is a longer-term measure of nutritional deprivation than underweight; (2) separate estimations for male and female children under age five to determine if malnutrition is explained by different factors for boys than girls; (3) research into the sequencing of interventions to improve child nutrition and into the costs of various interventions; (4) an in-depth study of the roles of democracy and women's status; (5) research on the roles that debt, structural adjustment, conflict, and HIV/AIDS play in Sub-Saharan Africa's rising rates of malnutrition; and (6) an unraveling of the "black box" of time-invariant factors to further explain why South Asia's prevalence of child malnutrition is so much higher than Sub-Saharan Africa's.

This research has found evidence of a feedback effect of child malnutrition—that is, that today's child malnutrition contributes to higher levels of child malnutrition in the future. Although the evidence is weak at present, the existence of this linkage suggests that reducing child malnutrition at a fast pace today should reduce child malnutrition in the future at an even faster pace. A seventh suggested area of future research is prospective studies that use household-level data to ascertain the existence of this linkage and to estimate how strong it is.

Finally, an indicator of national prevalences of food insecurity—based entirely on household food consumption or expenditures survey data—is needed to clarify the role of food security in child malnutrition and to identify where food insecurity is located and how it changes over time. While in the past data were not available to complete this task, with the increased frequency of household food consumption surveys the development of such an indicator is now possible.

A Note of Caution

Finally, a caution to users of this study's findings: the results apply only at the very broad level of the developing countries as a whole and, more tentatively, to the developing-country regions. Their applicability to specific populations at more disaggregated levels is unknown. Careful analysis and diagnosis are needed for understanding the causes of child malnutrition for each subpopulation of the developing world, whether it be a country, a subnational region, a community, a household, or an individual child.

Appendix: Supplementary Tables

Table 22—Cross-country studies of the determinants of health outcomes in developing countries

Study	Dependent variable	Method	Number of countries	Main findings	Limitations
Anand and Ravallion (1993)	Life expectancy, around 1985	OLS	22	Per capita income loses its significance as an explanatory variable once poverty and public spending on social services are controlled for.	Limited list of dependent variables may cause omitted variable bias. Small sample size. OLS estimation may lead to biased estimates
Subbarao and Raney (1995)	Infant mortality, 1985	OLS	72	Female education (lagged 5 and 10 years) has a strong effect on infant mortality; access to family planning, population per physician, and GDP per capita are significant but not as effective.	OLS estimation may lead to biased estimates. Combined estimation of basic and underlying determinants only gives partial (rather than total) effect of basic determinants.
Pritchett and Summers (1996)	Infant and child mortality, life expectancy, 1960–85	OLS, first-differences, country fixed-effects, and instrumental variables.	58–111 (184–368)[a]	Per capita GDP has a substantial positive impact on infant and child health; education levels are also important.	Does not allow breakdown of the path-ways through which average incomes influence health outcomes. Since GDP per capita facilitates educational investment, coefficient on GDP may not represent total income effect (biased downwards).

Notes: OLS = Ordinary least squares regression.
[a] Total number of observations.

Table 23—Cross-country studies of the determinants of child malnutrition in developing countries

Study	Dependent variable	Method	Number of countries	Main conclusion	Limitations
ACC/SCN (1993)	Underweight children, 1975–92	OLS on pooled, cross-section data	66 (100)[a]	Dietary energy availability, women's education, public expenditures on social services, and size of the child population under five are all important determinants; regional effects are statistically significant.	OLS estimation may give biased estimates.
ACC/SCN (1994)	Underweight children, 1975–93	Quasi first-differences	35 (79)	Growth in per capita income is an important determinant.	Small sample size.
Gillespie, Mason, and Martorell (1996)	Change in prevalence of underweight children, 1975–93	Quasi first-differences	35 (number of spells)	Growth in per capita income and (levels of) public expenditures on health services are significant determinants; energy availability (levels and changes) is not significant.	Combination of levels and change variables does not allow interpreta-tion of coefficient estimates.
Rosegrant, Agcaoili-Sombilla, and Perez (1995)	Underweight children, 1980–90	OLS on pooled, cross-section data	61 (183)	Dietary energy availability and social expenditures are significantly (negatively) associated with underweight rates, but women's education and access to safe water are not.	Use of predicted values from previous estimates means that significance and magnitude of parameter estimates are inaccurate.
Osmani (1997)	Stunted children, around 1990	OLS	45	Per capita income and women's literacy are important determinants of stunting; income distribution is not significant; low birth- weight accounts for South Asia's excessive malnutrition.	Inclusion of "low birthweight" variable in estimating equation and OLS estimation technique lead to biased parameter estimates.
Frongillo, de Onis, and Hanson (1997)	Stunted and wasted children, post1980	OLS	70	Dietary energy availability, women's literacy, and per capita GNP are significant determinants; results on health services differ by region. Women's literacy-squared, immunization rates, military population and dietary energy availability (only for Asia) significant for wasting.	OLS estimation may give biased parameter estimates. Combined estimation of basic and underlying determinants only gives partial (rather than total) effect of basic determinants.

Notes: OLS = Ordinary least squares regression.
[a] Total number of observations are given in parentheses.

Table 24—Regional groupings of developing countries

Region	Number of countries	Country
South Asia	7	Afghanistan, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Bhutan
Sub-Saharan Africa	44	Angola; Benin; Botswana; Burkina Faso; Burundi; Cameroon; Central African Republic; Chad; Comoros; Congo, Republic of; Congo, Democratic Republic of; Côte d'Ivoire; Djibouti; Eritrea; Ethiopia; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Reunion; Rwanda; Senegal; Sierra Leone; Somalia; Sudan; Swaziland; Tanzania; Togo; Uganda; Zambia; Zimbabwe
East Asia	14	Cambodia; China; East Timor; Indonesia; Korea, Democratic Republic of; Laos; Malaysia; Mongolia; Myanmar; Philippines; Singapore; Korea, Republic of; Thailand, Viet Nam
Near East and North Africa	20	Algeria, Bahrain, Cyprus, Egypt, Gaza Strip, Iraq, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, United Arab Emirates, Yemen
Latin America and the Caribbean	24	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Trinidad and Tobago, Uruguay, Venezuela
Total	109	

Notes: The regional classification of countries corresponds to that employed for IFPRI's IMPACT model projections. Countries with 1995 populations less than 500,000 are excluded.

Table 25—Explanatory variable means, South Asia, 1970, 1975, 1980, 1985, 1990, and 1995

Variable	1970 (1)	1975 (2)	1980 (3)	1985 (4)	1990 (5)	1995 (6)	Absolute change, 1970–95 (7)
Access to safe water (percent)	19.8	39.3	50.5	53.7	80.9	79.7	+59.8
Female secondary school enrollment (percent)	13.7	14.8	18.0	23.5	29.5	34.2	+21
Female-to-male life expectancy ratio	.970	.982	.992	1.00	1.014	1.023	+0.0537
Per capita dietary energy supply (kilocalories)	2,105	1,948	1,975	2,126	2,264	2,356	+251
Per capita GDP (US$ PPP)	674	682	724	768	962	1,136	+461
Democracy index (1 = least democratic)	5.17	5.17	5.48	4.83	5.24	4.10	–1.07

Note: These data are population-weighted means over all countries in the data set in the region.

Table 26—Explanatory variable means, Sub-Saharan Africa, 1970, 1975, 1980, 1985, 1990, and 1995

Variable	1970 (1)	1975 (2)	1980 (3)	1985 (4)	1990 (5)	1995 (6)	Absolute change, 1970–95 (7)
Access to safe water (percent)	21.6	26.6	29.8	33.5	42.9	48.8	+27.2
Female secondary school enrollment (percent)	3.6	6.5	10.6	16.4	15.8	19.0	+15.4
Female-to-male life expectancy ratio	1.072	1.070	1.069	1.066	1.058	1.054	−0.0177
Per capita dietary energy supply (kilocalories)	2,133	2,083	2,089	2,035	2,099	2,136	+2.8
Per capita GDP (US$ PPP)	950	1000	963	830	851	778	–172
Democracy index (1=least democratic)	2.26	2.45	3.10	2.01	2.13	2.44	+0.184

Note: These data are population-weighted means over all countries in the data set in the region (excluding Comoros, for whom population data are not available).

Table 27—Explanatory variable means, East Asia, 1970, 1975, 1980, 1985, 1990, and 1995

Variable	1970 (1)	1975 (2)	1980 (3)	1985 (4)	1990 (5)	1995 (6)	Absolute change, 1970–95 (7)
Access to safe water (percent)	30.5	46.2	52.6	68.4	67.1	66.5	+35.9
Female secondary school enrollment (percent)	17.7	34.8	36.3	34.3	42.0	59.8	+42.2
Female-to-male life expectancy ratio	1.032	1.032	1.038	1.048	1.051	1.051	+0.0189
Per capita dietary energy supply (kilocalories)	1,998	2,067	2,280	2,530	2,618	2,720	+722
Per capita GDP (US$ PPP)	628	739	938	1,138	1,582	2,494	+1,866
Democracy index (1=least democratic)	1.37	1.46	2.58	2.19	1.59	1.34	−0.0317

Note: These data are population-weighted means over all countries in the data set in the region.

Table 28—Explanatory variable means, Near East and North Africa, 1970, 1975, 1980, 1985, 1990, and 1995

Variable	1970 (1)	1975 (2)	1980 (3)	1985 (4)	1990 (5)	1995 (6)	Absolute change, 1970–95 (7)
Access to safe water (percent)	75.6	67.8	72.2	67.9	81.9	81.5	+5.9
Female secondary school enrollment (percent)	14.1	21.4	31.1	43.3	54.6	57.9	+43.9
Female-to-male life expectancy ratio	1.048	1.046	1.044	1.043	1.043	1.044	−0.004
Per capita dietary energy supply (kilocalories)	2,265	2,490	2,804	2,955	3,097	3,172	+907
Per capita GDP (US$ PPP)	1,654	1,932	2,397	2,462	2,647	2,653	+999
Democracy index (1=least democratic)	2.07	2.73	3.06	3.35	3.52	2.09	+0.0219

Note: These data are population-weighted means over all countries in the data set in the region.

Table 29—Explanatory variable means, Latin America and the Caribbean, 1970, 1975, 1980, 1985, 1990, and 1995

Variable	1970 (1)	1975 (2)	1980 (3)	1985 (4)	1990 (5)	1995 (6)	Absolute change 1970–95 (7)
Access to safe water (percent)	53.6	70.0	72.3	72.3	72.9	77.3	+23.7
Female secondary school enrollment (percent)	24.7	31.8	40.0	45.9	48.8	56.5	+31.7
Female-to-male life expectancy ratio	1.075	1.083	1.094	1.096	1.098	1.098	+0.023
Per capita dietary energy supply (kilocalories)	2,399	2,494	2,684	2,653	2,670	2,777	+378
Per capita GDP (US$ PPP)	3,581	4,361	5,085	4,359	4,684	4,849	+1,269
Democracy index (1=least democratic)	3.59	4.20	4.61	4.84	5.24	4.62	+1.032

Note: These data are population-weighted means over all countries in the data set in the region.

Table 30—Child malnutrition regressions: Comparison of fixed-effects and random-effects estimates (underlying-determinants model)

Variable	Fixed effects	Random effects
Access to safe water (*SAFEW*)	–.072	–.084
	(1.84)*	(2.33)**
Female secondary school enrollment (*FEMSED*)	–.232	–.180
	(3.51)***	(3.45)***
Female-to-male life expectancy ratio (*LFEXPRAT*)	–74.89	–101
	(1.83)*	(3.06)***
Per capita dietary energy supply (*DES*)	–.067	–.053
	(3.00)***	(2.56)**
DES^2	1.24E-05	9.06E-06
	(2.66)***	(2.14)**

Notes: The dependent variable is prevalence of underweight children under five. The number of observations for all regressions is 179 (63 countries). Absolute values of *t*-statistics are given in parentheses.
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

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